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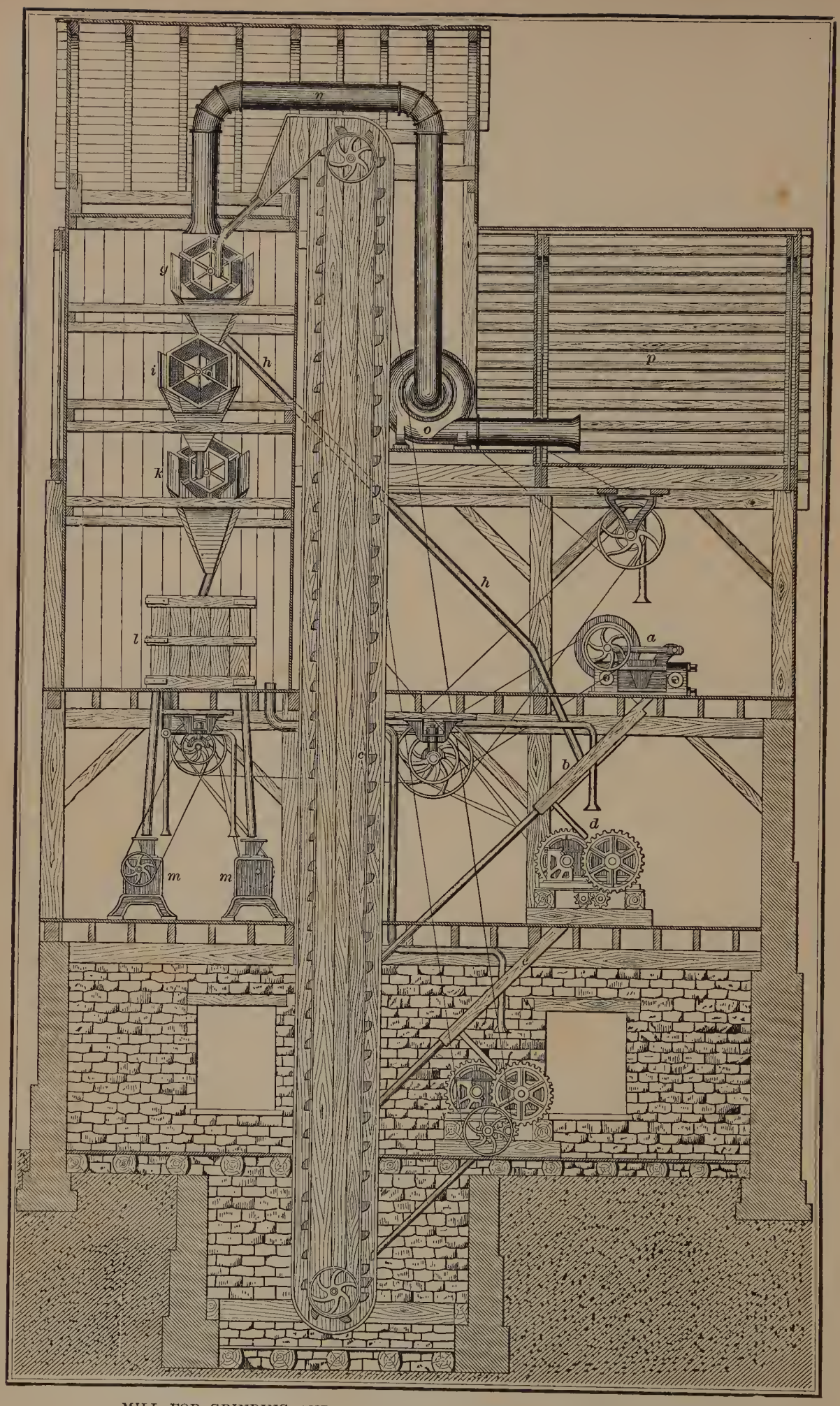

MILL FOR GRINDING AND CONCENTRATING ORE BY THE DRY PROCESS.

PLATE XXXIV.

See page 1567.

THE

PRACTICAL

DICTIONARY OF MECHANICS:

BEING

A DESCRIPTION OF TOOLS, INSTRUMENTS, MACHINES, PROCESSES, AND ENGINEERING; HISTORY OF INVENTIONS; GENERAL TECHNOLOGICAL VOCABULARY;

AND

DIGEST OF MECHANICAL APPLIANCES IN SCIENCE AND THE ARTS.

By EDWARD H. KNIGHT,

CIVIL AND MECHANICAL ENGINEER, ETC., U.S.

Illustrated

WITH UPWARDS OF FIVE THOUSAND ENGRAVINGS.

DIVISION IV.

"Thus Time brings all things, one by one, to sight,
And Skill evolves them into perfect light."

LUCRETIUS, Book V.

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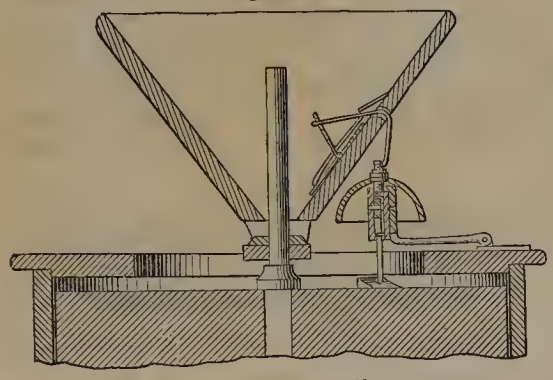
to turn off the power and stop the machinery when the grist is expended. Other patents have been granted for arrangements by which timely notice is given of the fact that the hopper is nearly empty.

In the example, a plate hinged to the side of the hopper is held down by the grist until the latter is about expended. The plate then rises, and its attached cord allows a stud to drop so as to be struck

Fig. 3150.



Taylor's Mill-Hopper Alarm.

by a projection on the stone at each revolution of the latter. This gives a rapid oscillation to the clapper, and sounds the alarm which announces that the grist is nearly expended.

In another case, a bell is so arranged within the hopper that when surrounded by the grain it is held stationary, but when uncovered is caused to ring by the tremulous motion of the hopper. The grain rests upon a float hinged near the bottom of the hopper. When the grain is about expended the float is raised by a weighted lever, and the spout of an upper hopper is opened to supply the lower one with grain.

Mil'li-net. A machine-made net. *Mill-net; bobbinet.*

Mill'ing. (*Machinery.*) 1. As in Webster, so in writers on mechanical construction, the term *milling* is applied: —

a. To an action such as that which upsets the edge of a coin, making the raised flanges which protect the ornaments in relief on the obverse and reverse sides of the coin.

b. To an action such as that which gives a fluting or crenation to the edge of the coin.

c. To a planing action by a circular cutter on metal. A mode of *shaping.*

The first is an expanding or upsetting, and the second is an indenting process, which is properly called *nurling.*

Milling, in the first sense stated, is performed upon an object in a lathe by the pressure of a burnisher or wheel, which turns over or upsets an edge, as in the case of the feather-edge on a tube or bezel which holds a lens or a jewel in its seat or setting.

The term *milling* is also applied to the machines in the mint which turn over the edges, at the expense of the diameter, and thus throw the faces a little into recess, so that the ornamental impressions are protected by the edges, and the coins when piled are enabled to stand steadily. The machine is described in its place under COINING (which see). Castaining's machine for milling coin was introduced into the French mint in 1685. See also *B,* Fig. 3151.

For *milling,* as a mode of planing to shape, see MILLING-MACHINE.

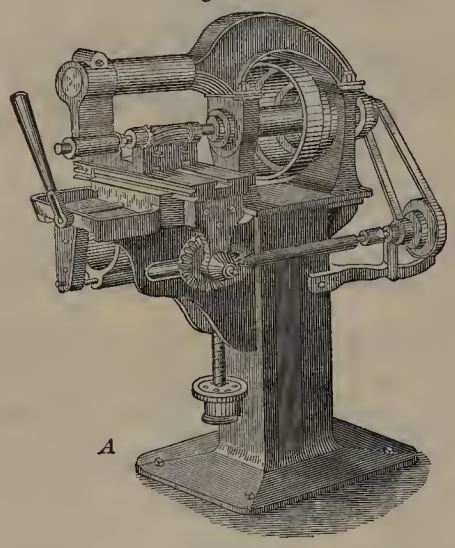
2. (*Porcelain.*) The mastication and grinding of slip for porcelain, giving it the final working to develop plasticity.

3. (*Cloth.*) A fulling process which condenses and thickens cloth at the expense of its area.

Mill'ing-ma-chine'. (*Machinery.*) A machine for dressing metal-work to shape by passing it on a traveling bed beneath a rotating serrated cylindrical cutter. The milling-machine occupies the same relation to metal that the planing or molding machine does to wood. In each case the work is reduced by a rotary cutter, whether the surface be plain or irregular. The use of the *milling-machine* has advanced greatly during the past ten years. They are now used as finishing tools in machinists' shops, but especially in the business of reducing to shape the forged, stamped, or cast pieces which are made by the thousands to an exact gage, and are built up into sewing-machines, fire-arms of various kinds, and other things too numerous to mention, which are made in pieces to size, and then *assembled.* They are largely used for finishing heads of bolts and set screws, shaping nuts, fluting taps or reamers, cutting key-seats.

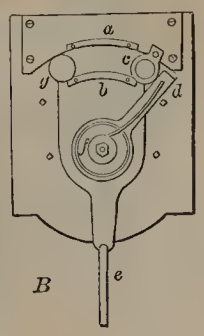
Their use has been much facilitated by the contemporary improvement in grinding-machines with emery-wheels. It has been found that by the use of these grinding-machines, milling-tools could be kept in perfect cutting order without, as was formerly necessary, drawing their temper and retempering. It has thus been rendered possible to greatly widen the application of these tools and to adapt them to work which would have cost much more to

Fig. 3151.



finish by methods formerly in vogue.

A (Fig. 3151) is a machine designed for milling where only a light or medium cut is required. The spindle is driven by a belt running on a cone-pulley without the intervention of gearing. The outboard center is supported by a stout cylindrical arm, secured to the head of the machine. The table is actuated by a hand-feed motion, and a rack and pinion worked by a lever in front constitutes the hand motion.



Milling-Machine.

B (Fig. 3151) is a machine for lettering or milling the edges of coins. In that used in the French mint two arc-dies *a b,* on which the inscription is

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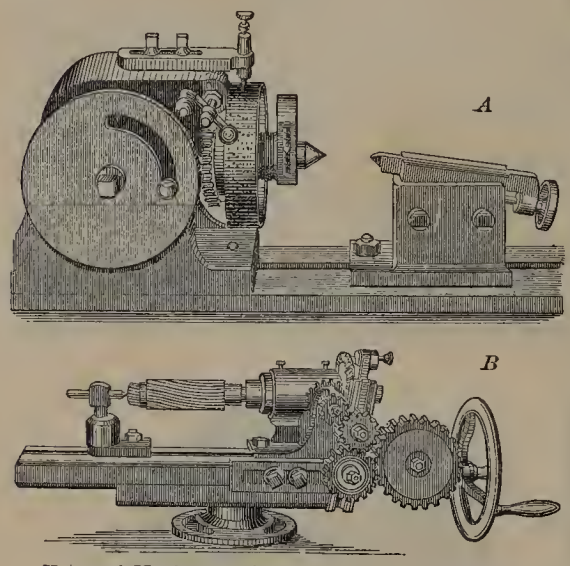
engraved in raised letters, one half on each die, but in reverse order, are immovably secured to the plate which bears the machine, and the distance between them is precisely equal to the diameter of the piece to be milled. *e* is a tube containing a pile of coins, which are successively pushed between the dies by the arm *d* attached to the lever *e*.

This lever, by its back and forth movement around the pivot *f*, also causes a rotary movement of the coin between the dies, during which the inscription, in sunken letters, is impressed on its periphery, after which it falls through the aperture *g* into a receptacle.

Fig. 3152, *A*, is a view, on a somewhat enlarged scale, of a *universal head*, which is adapted to be

Fig. 3152.

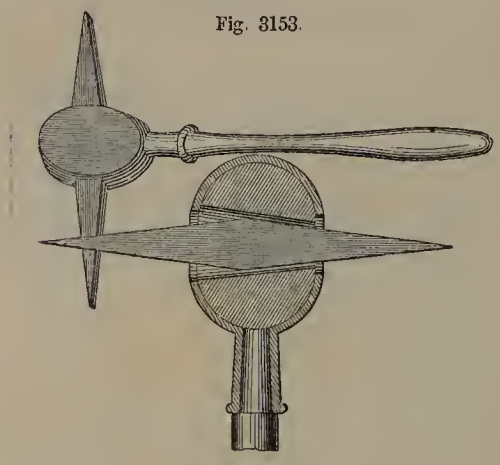


Universal Head and Spiral Cutter of Milling-Machine.

fastened to the platen of the machine. By chucking the object in this head, spur or bevel gear may be cut, and work milled at any angle or in any position.

B, in the same figure, is a *spiral cutter*, also designed to be attached, when required, to the platen of the machine. A piece of work is shown in position. By means of changeable gears the work is rotated beneath the milling-tool, so that a spiral cut is produced instead of a straight fluting. It is constructed to cut spirals 8 inches in length, right or left hand, of any pitch, from one turn in 2 inches to one turn in 6 feet. The spindle is hollow, allowing a $\frac{5}{16}$-inch rod to run through it.

Fig. 3153.



Mill-Picks.

Mill'ing-tool. A small indented roller mounted in a stock and used to nurl objects, such as the edges of screw-heads, by pressure against the latter when they are rotating in a lathe. A *nurling-tool.*

Mill-pick. A miller's tool for dressing millstones, giving to the buhrs the slightly serrated surface; an operation known as *cracking.* The steel is necessarily hard and tough, great skill in heating, hammering, and tempering being required.

Mill-race. The canal by which water is conveyed to a mill-wheel. Below the wheel the water is conducted away by the *mill-tail* or *tail-race.*

Mill-saw Vise. A clamp to hold a mill-saw while filing. It is intended to be bolted to a bench,

Fig. 3154.

Mill-Saw Vise.

and the jaws work on centers to enable the saw to be placed at an angle.

Mill-spin'dle. The vertical spindle of a grinding-mill, on which the runner is supported. See GRINDING-MILL.

Mill'stone. One of a pair of cylindrical stones for crushing grain in grinding-mills. The stone is peculiar, and comes mostly from France and from Georgia. See BUHR-STONE.

Many attempts have been made to introduce metallic cylinders, and stones differing from the buhr, in flouring-mills, but with indifferent success.

The stones are the "bed" and "runner," the upper being usually the moving stone, the lower being stationary. The relation of bed and runner is, however, sometimes reversed, the lower being the runner. See GRINDING-MILL, where illustrations occur.

The runner is supported by a *balance-rynd*, which stretches across the *eye* and rests upon the *spindle.* The upper part of the *spindle* is called the *cock-head*, and it is inserted into a cavity on the under side of the balance-rynd, called the *cock-eye.*

Millstones have various arrangements of grooves on their faces. The grooves are called *furrows*, and the intervening portions of the face are called *land.*

The system of *furrows* and *land* is called the *dress*, and this varies according to the custom of a country or the skill of the miller. Many varieties of dress are patented, and some will be cited presently. See Figs. 3154, 3155.

The *furrows* on the face of the millstone expedite the grinding action. The face of the millstone around the eye is usually somewhat sunken, so as to allow the grain to enter; this sunken space is called the *bosom.*

The *furrows* lead from the *bosom*, around the eye, to the *skirt* of the millstone, that is to say, to its periphery. It may be noted here, however, that in some modes of dressing, the *furrows* grow gradually shallower and disappear altogether before reaching the *skirt*, and leave a continuous *land* on the outer margin of the face.

A principal furrow leading from the eye to the skirt is called a *leader;* the branch furrow departing from the leader, nearest to the eye, is called a *second furrow;* a branch furrow departing from the *leader* nearest to the *skirt* is called a *skirt-furrow.* A *furrow* concave at bottom is called a *gouge-furrow.*

A *furrow* has one steep edge and one slanting

edge; the former is called a *track-edge*, and the latter a *feather-edge*.

A *leader* and its branches, occupying a segment of the face of the stone, is called a *quarter*, though not necessarily or usually occupying a fourth part of the face.

The operation of preparing the face of a stone is called *dressing*. Roughing the land face of a stone with a pick-hammer is called *face-cracking*.

The *draft* of a millstone dress is the degree of deflection of its furrows from a radial direction. Thus in a "7-inch draft" the *track-edges* are tangential to a 7-inch circle.

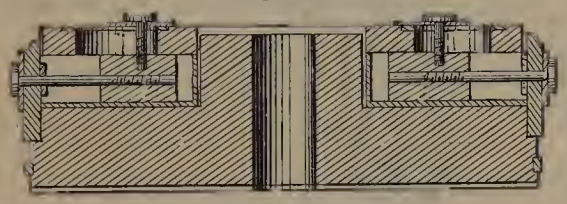
A 12-*quarter* or 14-*quarter dress* indicates a system of 12 or 14 sets of furrows.

One form of lower millstone at the Paris Exposition had sectoral openings covered with wire-gauze, to allow flour to escape as soon as fine enough without compelling it to pass clear to the outside.

The weight of an ordinary pair of millstones is from 1,300 to 1,700 pounds. They measure about 48 inches in diameter, are about 10 inches thick, and contain from 30 to 40 buhrs.

Mill'stone-bal'ance. A weight so placed as to balance other inequalities of weight in a stone, so that it may run true. In the example, weights

Fig. 3155.



Millstone-Balance.

placed opposite to the driving-point and to each other, at the four quarters of the stone, are moved in ways by set screws, operated from the outside on the band, and, being properly adjusted, the true balance is obtained.

Mill'stone-bridge. The bar across the eye of a millstone by which it is supported on the head of the spindle. A *balance-rynd*.

Mill'stone-dress. (*Grinding.*) *a*. The arrangement and disposition of the furrows in the face of a millstone.

b. The draft given to the furrows.

The object of the various kinds of dressing is to secure the proper proportional quantity of material on the stone from the eye to the skirt. The kinds of dress are known as the *quarter dress* and the *circular dress*. In the former the face is divided up into a number of sectors, each of which is known as a *quarter*, and has its own set of furrows. The advance edge of a furrow is the *leading edge*, the other is the *trailing* edge. See GRINDING-MILL.

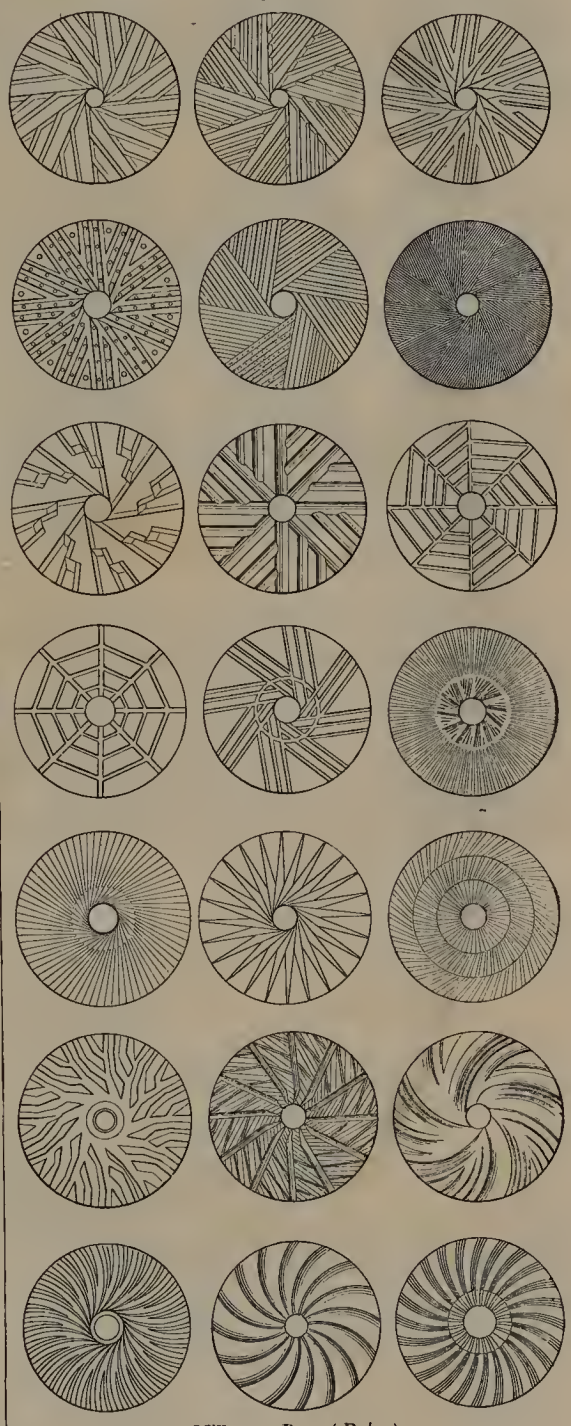
The querns of the Keltic and Roman inhabitants of Britain had notches, forming a *dress*.

Fig. 3156 is a collection of views of different millstones, which will not be described at length. The upper examples are *quarter* dress; then follow specimens of *radial-and-circular* dress, then a number of curved and circular systems.

In addition to the features involving direction are others, such as openings in the bed or runner, forming pockets, or for ventilation, or to allow escape of fine flour. Natcher's patent of 1858 is for ruling lines with a diamond on the *land* of the stone to give it a cutting quality.

In corn and feed mills with serrated iron plates for grinding, the dress is different, as shown in Fig. 3157. Many of these plates are frustums of cones or conoids.

Fig. 3156.



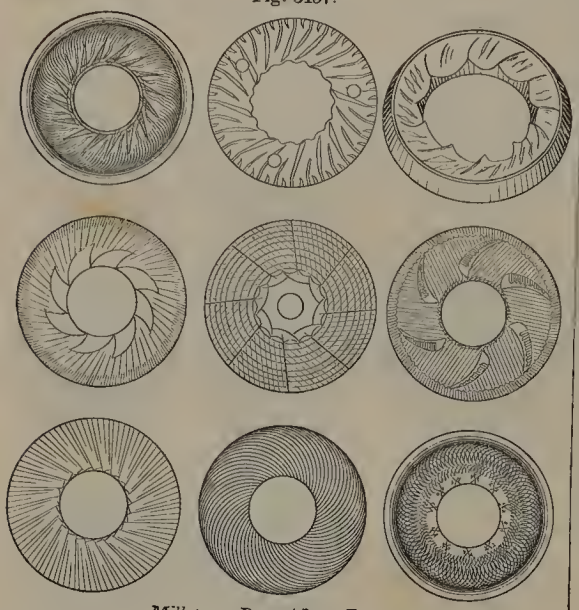
Millstone-Dress (Buhrs).

Mill'stone-dress'er. A machine for cutting grooves in the grinding-face of a millstone.

In one form of the machine, the lines radiating from the center are made by a tool raised and dropped by a cam and advancing automatically along a radial arm attached to a central axis.

A Swiss machine for dressing millstones is shown in Fig. 3158. The frame *A* has arms *b b* terminating in feet *c'*, which are provided with set screws. A tool-support *S* is pivoted to the center of *A*, and is adjustable by means of sector *B*, and slides on the arm *C* of the frame. Two disks at *K* carry diamonds

Fig. 3157.

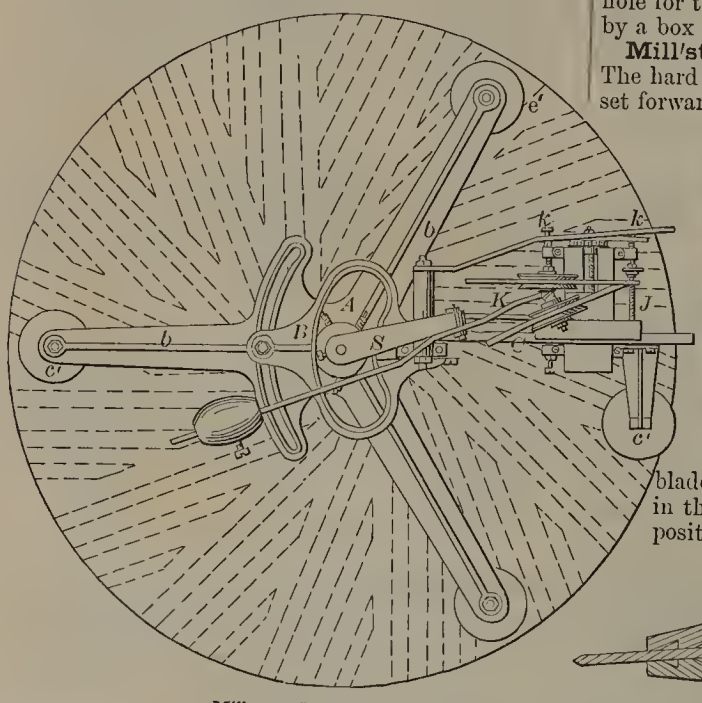


Millstone-Dress (Iron Plates).

or other hard stones on their peripheries, and are set in rapid revolution by belts from spindle *J*, which is revolved from any convenient shaft outside the millstone.

The cutting-disks being put in rapid revolution, the successive blows of the diamonds act in a manner similar to that of a hand tool, and parallel grooves are cut in the face of the stone. Three of these sets of parallel channels or grooves make one division of the stone. The guide-bar *C* is adjustable, so that

Fig. 3158.

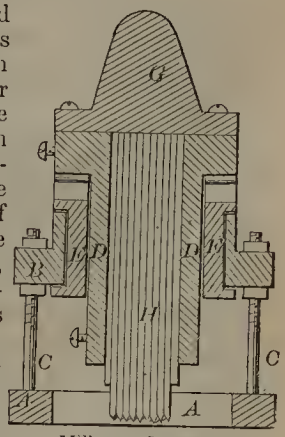


Millstone-Dresser.

the stone may have a right-hand or left-hand dress, as desired.

In the machine shown in Fig. 3159, a number of pick-plates of tempered steel *H* are held in a hollow block *D D*, which latter slides vertically in a holder *E E*. A cap fitting over the pick-plates and secured to the hollow block *G* is struck by a mallet when dressing, while the holder is pushed along on the guide. Standards *C C* with screw-heads permit the vertical adjustment of the holder when the points of the pick-plates become worn. *A A* is the bed, which rests on the millstone when the machine is in use.

Fig. 3159.

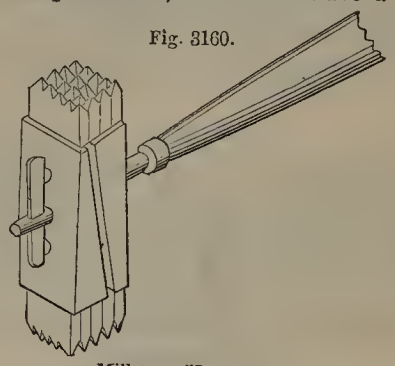


Millstone-Dresser.

Mill'stone-grit. A refractory sandstone of which the sides and hearth of a blast-furnace are composed.

Mill'stone-ham'mer. A tool for furrowing millstones. A millstone-pick. In the example shown, the blades have a central

Fig. 3160.

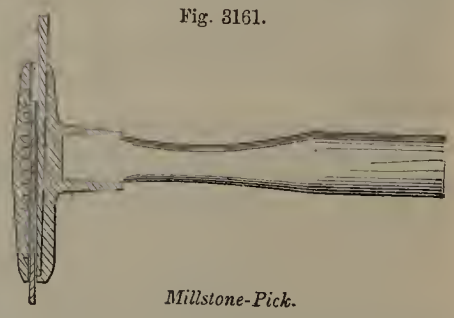


Millstone-Hammer.

hole for the reception of the handle, and are inclosed by a box whose sections have a diagonal junction.

Mill'stone-pick. A tool for dressing millstones. The hard steel blade is held in a stock, and may be set forward as it wears away, a lip on the heel of the

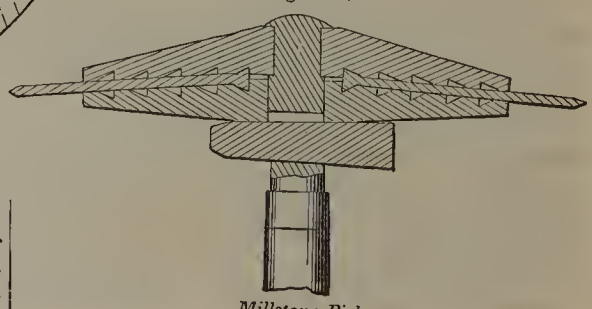
Fig. 3161.



Millstone-Pick.

blade setting in one or another of the notches in the stock. A wedge holds the blade in any position.

Fig. 3162.

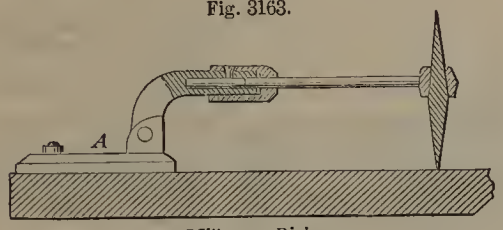


Millstone-Pick.

In Fig. 3162 the blades have conical heads, and are held by wedging the portions of the stock together.

Fig. 3163 is hinged to a bed-plate *A*, which slips over the stone while the pick is vibrated.

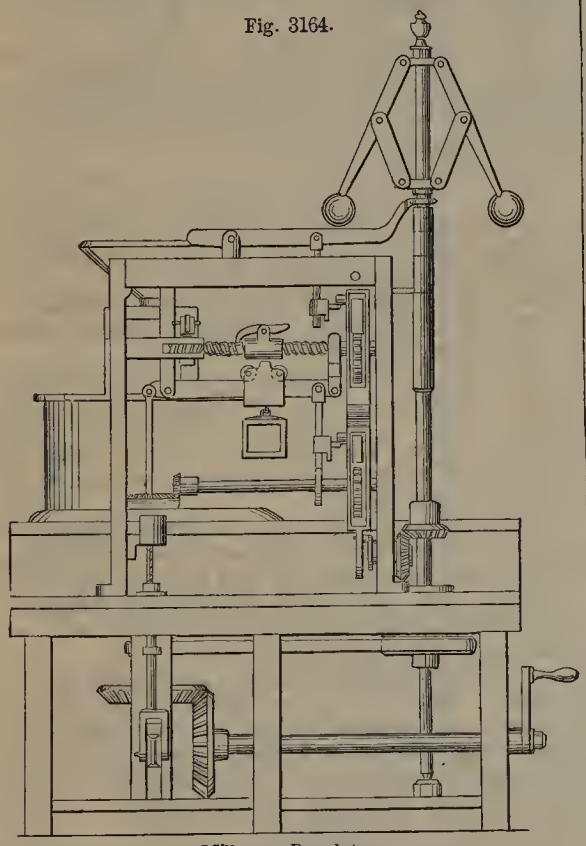
Fig. 3163.



Millstone-Pick.

Mill'stone-reg'u-la'tor. One for graduating the feed of the grain to the rate of motion of the runner. The governor is operated from the mill-gear, and connects, by means of a screw-shaft, a traveling poise, and a scale-beam that will adapt both the feed of the grain and the set of the stones to the varying speed of the runner, caused by changes in the motive power. When the mill is set to grind a particular grade of flour, if the motive power fails to exert the same force on the stone, the governor at once reduces the feed, so that the grade may be continued, though less grain will be ground. The principle is, that the greater the power the greater the capacity for grinding, the feed being increased in

Fig. 3164.

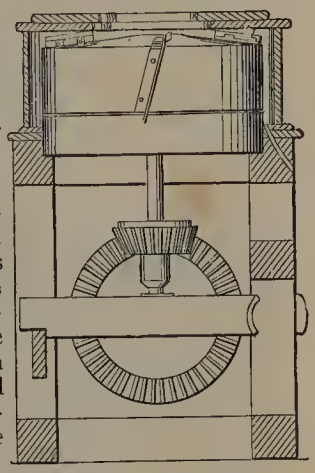


Millstone-Regulator.

proportion the pressure of the runner on the bed-stone must be likewise increased; to do this, the poise is moved in allowing the spindle to sink a little, permitting a larger proportion of its actual weight to rest upon the grain and flour which intervene between the stones.

Mill'stone-ven'ti-la'tor. An arrangement for conducting a blast through the eye of the runner and out at the *skirt*, to cool the floor and facilitate delivery. The invention is described in the patent of Houyet and Gendebein, 1844; and there have since been many variations in the details. In Fig. 3165, the millstones are ventilated, while running, by hinged inclined wings upon the top of the runner, in connection with inclined wings upon the periphery of the stone. See also English patents, 10,163 of 1844, 11,084 of 1846; French patents of Cabanes, May 29, 1845, and May 26, 1846.

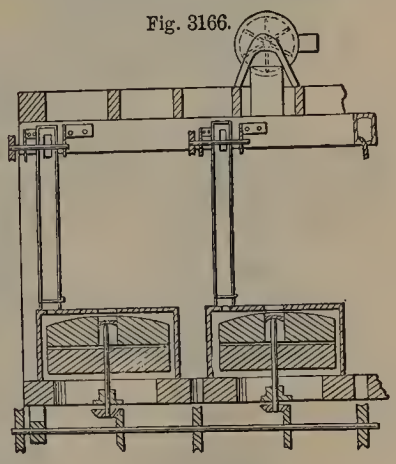
Fig. 3165.



Millstone-Ventilator.

In Fig. 3166, the drums are made air-tight, except at the eye of the stones; the air is exhausted by fans placed in pipes connecting with the sides of the drums, and forced into a cooling-box from which it is drawn off by a large fan.

Fig. 3166.



Ventilating-Millstones.

In Fig. 3167, the devices are shown somewhat more in detail. Air is introduced through an annular duct *T* around the feed-tube *S* into an air-chamber bounded by two cones *M N*, and thence by ducts *P* and spouts *P' P'*, to the space between the stones.

Mill-tail. The *tail-race* of a mill which conducts the water away from the wheel.

Mill-wheel. The water-wheel which impels the machinery of a mill.

For specific index of wheels, see WATER-WHEEL.

See also list under HYDRAULIC ENGINEERING AND DEVICES.

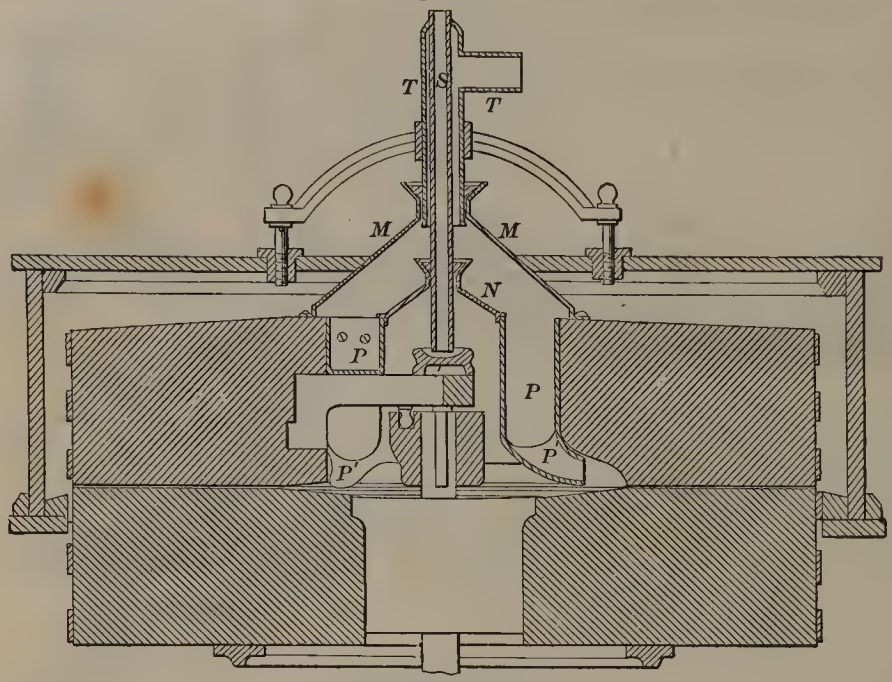
Mill'wright's Com'pass. A dividing and scribing tool used by millstone manufacturers in laying off the dress on the face of stones. See MILLSTONE-DRESS.

Min-ar'gent. Copper, 1,000; nickel, 700; tungsten, 50; aluminium, 10. The first three ingredients are melted together, then run off in a granulated form, and again melted, adding the aluminium and about 1½ per cent of a flux composed of one part borax and one part fluoride of calcium; these proportions of borax are reduced as the fusion proceeds.

It is one kind of aluminium bronze. (See list of Farmer's aluminium alloys, page 71.) In these copper is the first metal, aluminium the second, and silver, iron, nickel, and zinc in various combinations, so as to give the desired character to the metal, according to its intended duty.

A number of other jeweler's alloys are to be found in a table on page 63; white-metal alloys on same

Fig. 3167.

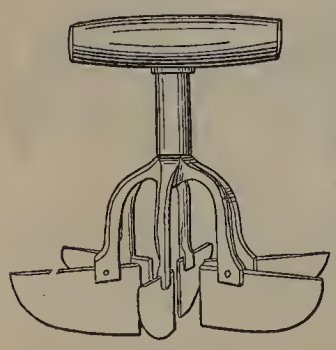


Millstone-Ventilator.

page ; alloys under specific names may be found in the list under METALLURGY.

Minc'ing-knife. A knife with a curved blade or blades for mincing meat and fruit in a wooden bowl.

Fig. 3168.



Mincing-Knife.

Minc'ing-machine'. A machine for chopping food into small fragments. A sausage-machine.

Mincing-machines operate by revolving knives in a barrel which has stationary intervening knives; by guillotine knives acting upon a block rotating on a vertical axis. The *malaxator* or *masticator* is more truly a grinding process, its object being to mash and disintegrate the fibers. See MEAT-CUTTER ; MEAT-CHOPPER ; SAUSAGE-MACHINE.

Mine. 1. A subterraneous passage from which coal, metals, metallic ores, are obtained.

Depth of Mines.

	Feet.
Eselchaet, Bohemia (silver)	3,778
Dunkenfield, England (coal)	2,504
Pendleton, England (coal)	2,504
Linden, Prussia (salt well)	2,331
Tresavean, England (copper)	2,112
Durham, England (coal)	1,773
Valenciana, Mexico (silver)	1,686
Crown Point, Comstock lode, Nevada (silver)	1,400
Santa Rosa, Mexico (silver)	1,200

2. Crude ironstone, known as *raw*-mine, *green*-mine, *burnt*-mine, etc.

3. (*Fortification.*) An excavation toward or under the rampart of a fortress to contain an explosive charge, to destroy or effect a breach in an enemy's works. Mines executed by the defenders of a fort, to intercept those of the assailants, are *countermines*.

The place of deposit is the *chamber ;* and the passage leading thereto the *gallery.*

Military mines are known as, —

Common. Double. Triple.
Defensive or *countermines.*
Offensive.
Conjunct, several acting simultaneously.
Suffocating or *camouflet.*
Undercharged.
Over or *surcharged*, producing a crater whose radius is greater than the line of least resistance.

Military mining was practiced in very early times. It is represented in the Assyrian sculptures. The Persians and Romans adopted it extensively ; the latter as early as the fifth century B. C. They had no explosives.

Herodotus mentions the Persian mines during the siege of Barca in Libya, and the skillful countermining of the garrison. (IV. 200.)

Mine-cham'ber. The place of deposit of the charge.

Min'er-al Cot'ton. A fiber formed by allowing a jet of steam to escape through a stream of liquid slag, by which it is blown into fine white threads, sometimes two or three feet in length. These threads, though somewhat elastic, readily break up into smaller ones, and, the color of the substance being white, the appearance is that of a mass of cotton.

Being a poor conductor of heat, owing to the retention of air in its interstices, it is suggested as a covering for steam-boilers and pipes.

Min'er-al Tar. Bitumen of a tarry consistence.

Min'er-al Wa'ters. Among the mineral waters are comprised the follows : —

Carrara, blue-lick, carbonic acid, chalybeate, Kissingen, lemonade, potash, Saratoga, seidlitz, seltzer, soda, Vichy. A number of the above are natural waters, but are simulated by adding to water the ingredients in the proportions of the natural, as ascertained by analysis.

Iron, sulphur, lime, soda, magnesia, lithia, are the usual ingredients of the natural mineral waters. The ingredients principally used in the artificial are, carbonic acid, carbonates of soda and magnesia, bicarbonate of potash, chloride of sodium, salts of iron, tartaric acid, tartrate of soda.

"The water was cool enough [a spring in the vicinity of Tolon Noor], but had a pungent hydrochloric odor, reminding me of some I had once drank in the Pyrenees, and which was so very nauseous and ill-smelling that it was sold in the chemists' shops in France at 15 sous a bottle." — *Abbé Huc's Travels in Tartary.*

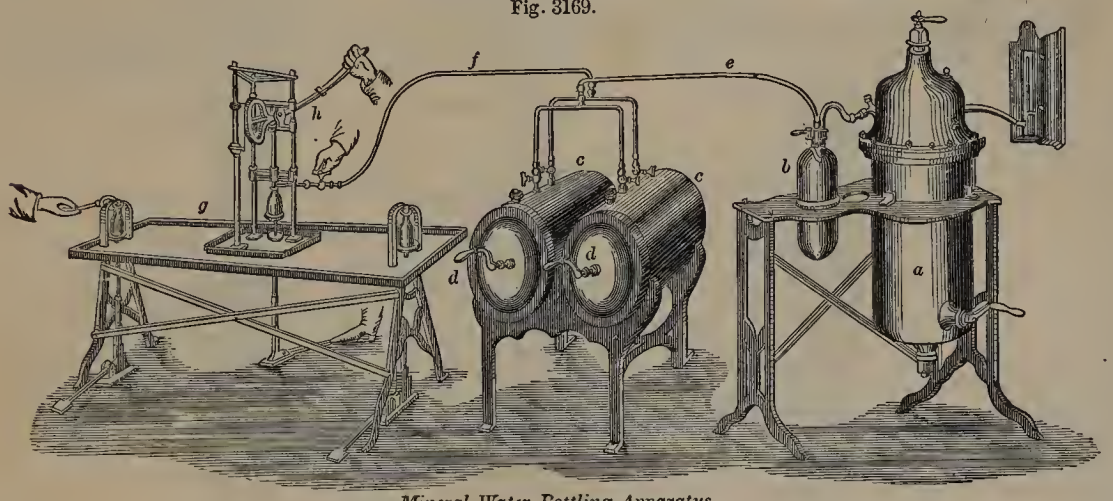
The passage in Genesis xxxvi. 24, properly rendered, favors the opinion that Anah made the discovery of warm mineral springs in the wilderness while hunting for the asses of Zibeon, his father. Moses records the fact as sufficiently worthy of mention, and it is probable that in the intervening 300 years they had acquired considerable notoriety in the cure of chronic complaints. See Dr. Thompson's "Researches in Palestine."

Berzelius, the Swedish chemist, a yearly visitor to the Carlsbad waters, is believed to have been the first to make a successful imitation of mineral water. Struve did the same shortly afterward. The first manufactory was established by Goser, an apothecary at Geneva, about 1790, who sold annually 40,000 bottles of Seltzer. Struve soon decided to devote himself to this speciality, and obtained patents in the chief European countries.

In the modern process of manufacturing mineral waters, carbonic-acid water is first made. The various chemicals are dissolved in a certain order, and some notable ingredients are produced by resulting chemical combinations, as, for instance, in a water containing chloride of sodium and carbonate of baryta, the latter would by itself dissolve with great difficulty, so that chloride of barium and carbonate of soda are introduced instead. By chemical reaction the chlorine and carbonic acid change places. By this means phosphate and fluate of lime, flint, compounds of barytes, silicates, and other very insoluble materials may be dissolved. The chemicals are usually grouped together before being placed in the water; thus each spring requires two, and sometimes more, separate solutions or mixtures. These concentrated solutions are largely made by Hanbury Smith and others, and are sold to druggists with directions for use. The price of these solutions to the retailers is $1 per quart, sufficient to make five gallons, or eighty glasses. The cost to the retailer is about three cents per glass, for he must have an apparatus for the aëration of the water. The subject belongs to our scheme only as far as the apparatus is concerned. See AËRATED WATERS.

The accompanying engraving represents a full set

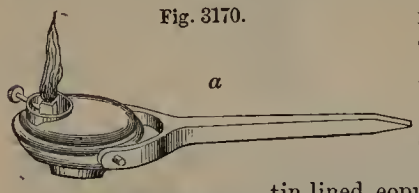
Fig. 3169.

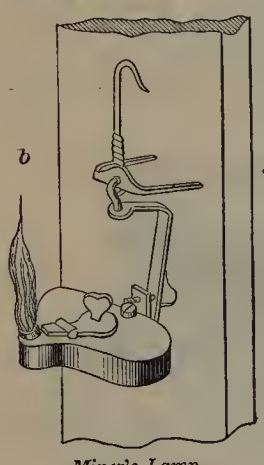


Mineral-Water Bottling-Apparatus.

of apparatus for the manufacture and bottling of mineral water. *a* is the gas-generator, which has an opening at top for introducing the chemicals, and at bottom an agitator and crank; it is also provided with a safety-valve and pressure-gage. From the generator the gas passes into the purifier *b*, containing a re-agent for absorbing other gases from the carbonic acid, and is thence conducted by the pipe *c* into the tin-lined copper fountains *c c*, containing the water to be aërated; these have cranks *d d* operating agitators in order to hasten the absorption of gas. The pipe *f*, provided with a cut-off cock, conducts the aërated water to the bottling bench *g*, where the cork is inserted by depressing the lever *h*, and wired by the device seen to the left of the bench.

Fig. 3170.





Miner's Lamp.

See AËRATOR; CORKING-MACHINE; BOTTLING-APPARATUS.

Mineral water may be corked from common soda-fountains with nearly the same facility as from an apparatus constructed for this purpose.

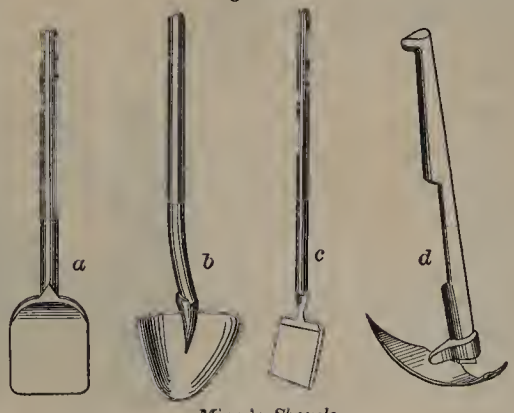
Min'er's Ham'mer. A form of hammer for the use of the miner. Some are shown at *h i j*, Fig. 3178.

Min'er's Lamp. In mines not subject to the collection of fire-damp unprotected lights are used. *a b*, Fig. 3170, are suspensory lamps of the French coal-mines. In many of the German mines the candle is carried on the front of the hat; in some others in a sconce; in others in a cleft stick. Customs vary.

Min'er's Pick. A form of pick or mattock used by miners. *a b c d e f g k l*, Fig. 3178.

Min'er's Shov'el. A form of shovel for miners. (*a b*, Fig. 3171.) See also *p q r*, Fig. 3178.

Fig. 3171.



Miner's Shovels.

c d are German miner's shovels.

Min'er's Wedge. A metallic plug used in opening seams, splitting masses, etc. See *m n o*, Fig. 3178. See also GAD.

Mine-tin. The natural tin found in gangues.

Min'i-a-ture. (*Fine Arts.*) A painted portrait on a small scale. A "picture in little," as Hamlet says.

Min'i-a-ture-tel'e-graph. One on a small scale, used for domestic, household, office, manufactory, or warehouse purposes. A size larger is the private telegraph, by which an office communicates with a distant manufactory, or a house with a police or fire-alarm station. See OFFICE-TELEGRAPH.

Min'ie-bul'let. Invented at Vincennes by M. Minie about 1833. See BULLET, *c*, Fig. 969.

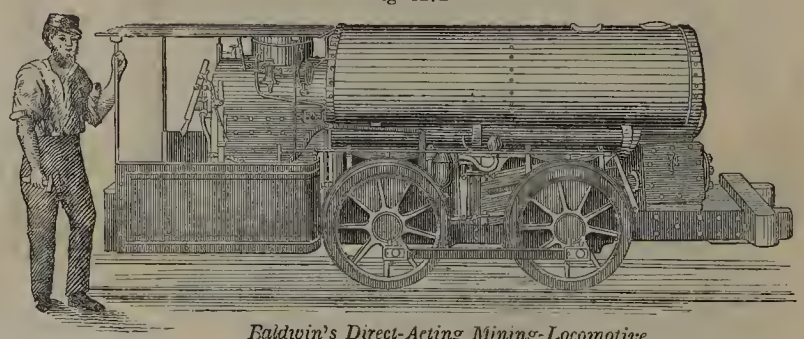
Min'i-mum Ther-mom'e-ter. A thermometer constructed to register the lowest point reached between observations; as Rutherford's or Six's. See THERMOMETER.

Min'ing Ap-pli'an-ces and Terms. See under the following heads: —

Adit.
Anticlinal line.
Arch.
Astel.
Astyllen.
Attle.
Auget.
Back.
Bank.
Bar.
Barrow.
Basset.
Batch.
Bed.
Bede.
Bedway.
Bend.
Blasting.
Blind level.
Bonney.
Bord.
Bottom-lift.
Bottoms.
Brace.
Branch.
Brattice.
Breast.
Brob.
Brood.
Bunch.
Burden.
Cage.
Case.
Cat-head.
Cauf.
Caunter-lode.
Channeling-machine.
Charger.
Cistern.
Claying-bar.
Coal-boring bit.
Coal-breaker.
Coal-cutting machine.
Coal-mining machine.
Coal-screen.
Coal-washing machine.
Coffering.
Coffin.
Corbond.
Corf.
Costeening.
Counter.
Course.
Cow.
Cradle.
Creaze.
Creep.
Cribbing.
Cribble.
Crop.
Cross-course.
Cross-cut.
Cross-lode.
Crow-bar.
Cutting.
Dan.
Day-level.
Dead-ground.
Deads.
Dean.
Dike.
Dip.
Dip-head level.
Down-cast.
Drift.
Dropper.
Drowned level.
Dums.
Fang.
Fanging.
Fault.
Flang.
Flookan.
Floran.
Fluke.
Foge.
Gad.
Gallery.
Gangue.
Ginging.
Goaf.
Gob.
Gobbing.
Gold-mining.
Gold-washer.
Grain-tin.
Grapnel.
Griddle.
Gunnie.
Gurnies.
Hade.
Halvans.
Hanging-side.
Hard pyrites.
Hard salt
Heading.
Hitch.
Hogger-pipe.
Holing.
Horns
Hushing.
Hutch.
Jamb.
Jinny-road.
Jump.
Jumper.
Keeve.
Kibble.
Knock-stone.
Launders.
Lead.
Leader.
Leap.
Ledge.
Ledger.
Level.
Lode.
Lorry.
Madrier.
Maundril.
Measure.
Meir.
Mine.
Miner's lamp.
Miner's hammer.
Miner's pick.
Miner's shovel.
Miner's wedge.
Mining-machine.
Mining-pump.
Mining-tools.
Monton.
Mother-gate.
Nicking-trunk.
Nip.
Nitro-glycerine.
Nog.
Outcrop.
Panel.
Pick.
Pick-hammer.
Pillar.
Pipe-vein.
Pit.
Pitch.
Pit-work.
Platt.
Polroz.
Post.
Post and stall.
Prill.
Pryan.
Punch.
Quarrying-machine.
Ragging.
Rib.
Riddle.
Rider.
Rim.
Ringer.
Rise.
Rock-boring tool.
Rock-drill.
Rock-drilling machine.
Rolley.
Room.
Safety-case.
Safety-fuse.
Scarcement.
Scraper.
Scrin.
Seam.
Shaft.
Shambles.
Shearing.
Sheers.
Shift.
Shoad.
Shot.
Sill.
Skip.
Skip-shaft.
Slicking.
Slimes.
Slip.
Slope.
Smift.
Snoft.
Sole.
Sollar.
Sough.
Spalling.
Spawl.
Spend.
Spire.
Squat.
Stall.
Stannary.
Stemples.
Stone-channeling machine.
Stone-quarrying machine.
Stope.
Stopping.
Strake.
Stream-work.
Strike.
String.
Stull.
Sump.
Sump-fuse.
Sump-shaft.
Synclinal line.
Tacklers.
Tamping.
Thirling.
Thread.
Thrust.
Thurl.
Tram.
Tribute.
Trogue.
Trommel.
Trouble.
Trunk.
Trunking.
Tub.
Tubbing.
Tug.
Tunneling.
Turn.
Tut-work.
Underlie.
Vein.
Vein-stone.
Vugh.
Wall.
Winch.
Winning.
Winze.
Witts.

Min'ing-lo'co-mo'tive. One adapted for drawing wagons on the tramways or rails of mines, made very low to adapt it to run in the galleries of passages. The one shown has a gage of two feet six inches; hight above rail, five feet four inches; width over all, five feet one inch; adapted to burn

Fig. 3172.



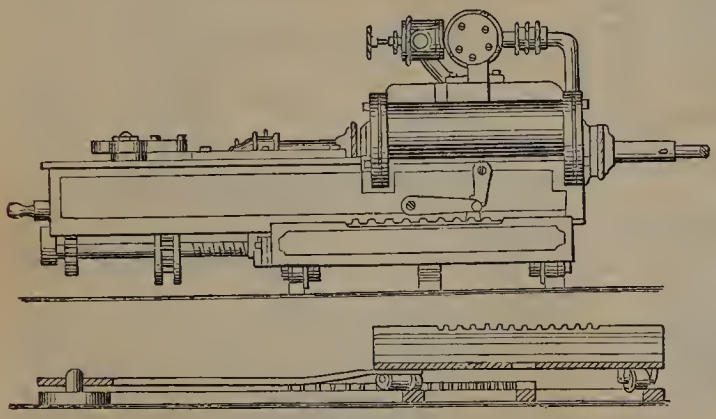
Baldwin's Direct-Acting Mining-Locomotive.

anthracite or bituminous coal or coke. It will pass curves of twenty-five feet radius, and haul on a level track in good condition three hundred and forty tons of cars and load.

Min'ing-ma-chine'. An apparatus provided with picks or cutters to cut grooves in rock or coal, after which the material is to be pried out or detached by wedges, as in coal-mining and working quarries.

In Fig. 3173, the engine moves on a track parallel with the breast of coal or stone, and a forward adjustment is made after each traversing cut. The chisels are worked alternately by their respective engines, their stocks being connected to a walking-beam, and have weighted pistons sleeved upon them. The steam is changed as the piston passes a certain point, and is the means of working the valve. The walking-beam actuates

Fig. 3173.

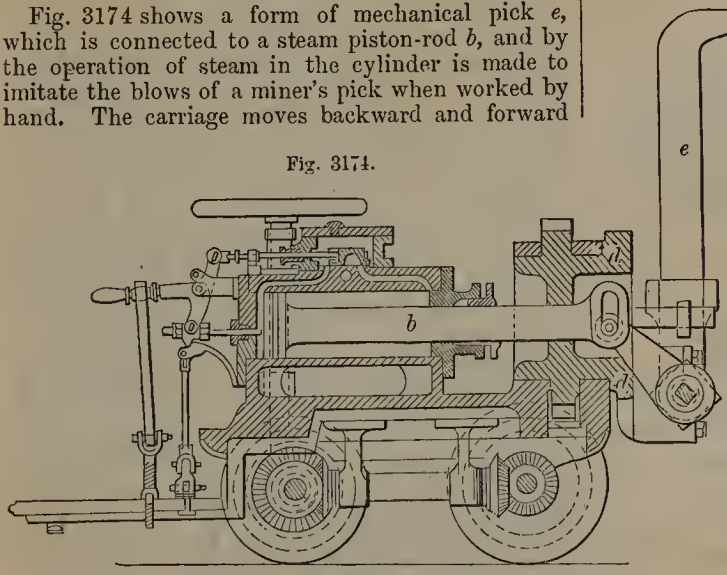


Mining-Machine.

the traversing devices. The blow of the chisel is similar to that of a drill.

Fig. 3174 shows a form of mechanical pick *e*, which is connected to a steam piston-rod *b*, and by the operation of steam in the cylinder is made to imitate the blows of a miner's pick when worked by hand. The carriage moves backward and forward

Fig. 3174.

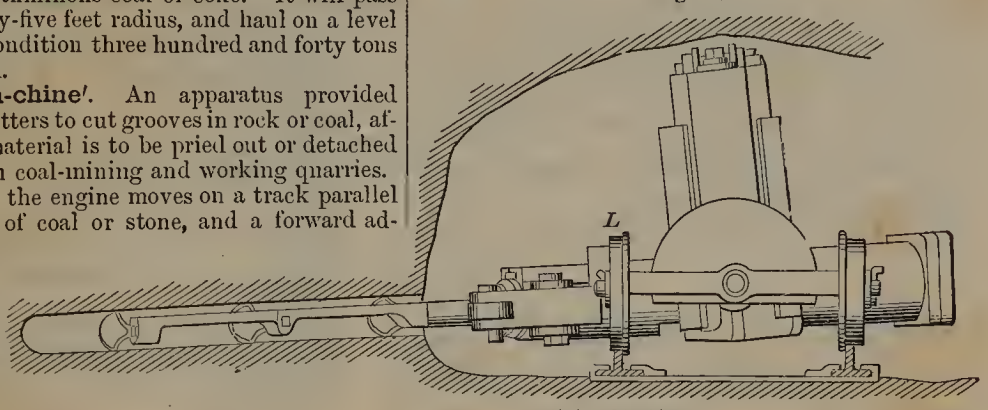


Mining-Machine.

on wheels, and the pick or cutter slides sidewise in the ways *d d*.

The machine shown in Fig. 3175 is operated by

Fig. 3175.



Mining-Machine.

hydraulic pressure, in the cylinder *L*. The hydraulic engine gives a steady thrust-motion to the tools; the position of the machine during the thrust is maintained by a holdfast, which is pressed against the roof during the cutting action of the tool or tools, and released therefrom to allow the machine to move forward during the return or back stroke of the tool or tools; the movements of this head or feeler and those of the drill are obtained from the pressure of water in the cylinder.

For other machines of this character, see COAL-MINING MACHINE.

Min'ing-pump. Pumps for mines and water-works have been on the most extended scale, and the former were for a long time the principal objects upon which the steam-engine was employed. The successive improvements of Worcester, Savary, Newcomen, and Watt were all directed toward one object, that of lifting water, which preceded by many years the useful application of the steam-engine to the purposes of locomotion, either upon land or water. The mines of Cornwall (which were worked by the ancient inhabitants, 3,000 years ago) were drained by means of the Savary apparatus and the atmospheric engines of Newcomen. Here also Watt and Boulton sent their engines, with such a guaranty of comparative economy in fuel, that they agreed to take as pay the value of one third of the proved saving of coal as compared with the Newcomen engine. This saving was found to be 75 per cent, and amounted to $35,000 yearly. The Cornish miners succeeded in cheating Boulton and Watt out of the greater part of their dues, and became rich. See STEAM-ENGINE.

At the present day the Cornish pumping-engine stands at the head of the list in effective economical performance, and the "duty" is reported in tabulated form, monthly. See DUTY.

The useful effect of the Cornish pumping-engine has been more closely observed and recorded than that of any other engine.

When Boulton and Watt's patent expired, the best of their engines in Cornwall were doing an

average duty of 24 millions of pounds of water raised 1 foot high by 112 pounds of Welch coal.

The rate deteriorated for a while, owing, it is said, to the absence of Mr. Murdoch and some other highly skillful men. Mr. Murdoch will be recollected as the great gas-engineer, and a successful builder of a locomotive in early times.

Captain Lean is credited with a general advance which soon afterward took place.

The tabulated results for the years 1812 – 1843 are as follows: —

Year.	No. of engines.	Average duty.	Average duty of the best engine.	Year.	No. of engines.	Average duty.	Average duty of the best engines.
1812	21	23.0		1828	57	44 1	91.4
1813	29	23.2	31 4	1829	53	49.6	91.6
1814	32	24.5-	38.1	1830	56	51.5	92 8
1815	35	24.4	34.1	1831	58	51.6	84.6
1816	35	27.4	38.6	1832	59	52.6	101.1
1817	35	31.5	49.5	1833	56	55.4	100.3
1818	33	30.2	46.8	1834	52	56.9	108.1
1819	40	31.3	47.6	1835	51	56.9	109 1
1820	46	34.1	49 1	1836	61	55.4	101.6
1821	45	33.6	50.9	1837	58	55.9	103.8
1822	52	34 4	50.6	1838	61	58.0	100.2
1823	52	33 6	50.0	1839	52	65.4	92.6
1824	49	33.7	51.8	1840	54	64.3	97.2
1825	53	33.1	54.0	1841	56	65.1	121.3
1826	51	33.3	53.8	1842	49	64.0	127.9†
1827	51	33.2	71.0*	1843	36	71.4	114.4

* Wolf's and Grose's improvements.

† Wolf's combined double-cylinder engine, cut off at one-tenth stroke. United mines at Gwennap.

The following table, compiled by S. Hughes, C. E., gives the duty of a number of pumping-engines in different large cities on each side of the Atlantic: —

Duty of Condensing Pumping-Engines.

	Millions of lbs. raised 1 ft. high by 112 lbs. of coal.
East London Water-Works, single-acting Cornish engine, 1836	105.7
East London Water-Works, Boulton and Watt	46.6
Haarlem Mere, Holland	89.4
Average of 36 Cornish engines, 1843	71.5
Cincinnati direct-action	53.6
Buffalo Cornish bull engines	37.0
Boulton and Watt's non-expansive rotative engine, Albion Mills, London, 1786	25.8
Spring Garden, Philadelphia, 1832	24.6
United States Dry-Dock engine, Brooklyn	22.4
Grand Junction Water-Works engines in 1849	46.8
Southwark and Vauxhall engines in 1849	69.6
Beardmore's exemplar Cornish engine	83.4
Beardmore's duty of Cornish engines at London Water-Works	56.25
Fowey Consols 50-inch cylinder-engine of 103-horse power, experimented on by Mr. Wicksteed, and worked at a power of 26½ horses	130.2
Holmbush 80-inch cylinder = 251 horses, worked at a power of 62 horses	122.4
Estimated duty of 72-inch cylinder condensing-engine for Brooklyn Works	35.5
Engines at the East London Works in 1850 from Mr. Wicksteed's evidence	63.8
Engines at the same works before the use of the Cornish engines	26.9
Average duty of Cornish engines (Lean, 1854)	53.7
Duty of best engine, from Lean, 1854	77.0
Duty of Cornish engine (Browne, 1855)	69.7
Duty of best engine, from Browne, 1855	101.4
Pittsburg high-pressure non-condensing engines, 1852: —	
Upper Water-Works	19.9
Lower Water-Works	19.1
Allegheny City	19.2
Detroit	17.3
To which may be added, —	
Worthington duplex engine, Newark, N. J.	76.6
Brooklyn, N. Y., double-acting beam, No. 1	60.1
Brooklyn, N. Y., double-acting beam, No. 3	72.0
Philadelphia, Spring Garden, Cornish	58.9
Belleville, Jersey City, Cornish	62.8
Hartford, Conn.; crank. Mean of three experiments	61.7
Cambridge, Mass.; double-cylinder. (Mean)	67.2

In considering the above, it must be recollected that the quality of coal varies, and the bushel may vary in weight; calculations have unfortunately been made at 94, 100, and 112 pounds.

See also COMPOUND ENGINE; DUPLEX ENGINE; DRAINING-ENGINE; PUMPING-ENGINE.

Cost of raising Water by Steam-Power.

	Gallons.	Hight in feet.	Cost.	Coal per 2,240 lbs.
East London Water-Works	1,000,000	100	$ 3.00	$ 2.52
Liverpool	1,000,000	100	4.08	
Wolverhampton	1,000,000	100	8.40	1.80
Southwark	1,000,000	100	2.88	2.40
Grand Junction	1,000,000	100	5.52	3 84

Of the pumps for mining purposes may be cited, (1) the common lift-pump, made on a scale proportionate to its work, but in no essential respects differing from that in ordinary use. Its piston is a valved bucket, being perforated for the passage of the water. See LIFT-PUMP; CORNISH ENGINE.

(2.) A lifting-pump with a plunger; that is, one not perforated, but acting as the ordinary piston.

The piston *b* (see *A*, Fig. 3176) works in a barrel *a*, communicating by a passage *d* with a valve-chamber *e*, to which are attached the supply and discharge pipes *i h*. The chamber has two valves *g f*, which act as induction and eduction, — one opening to admit water from the well as the piston descends, and the other allowing the water to escape into the discharge-pipe as the piston ascends.

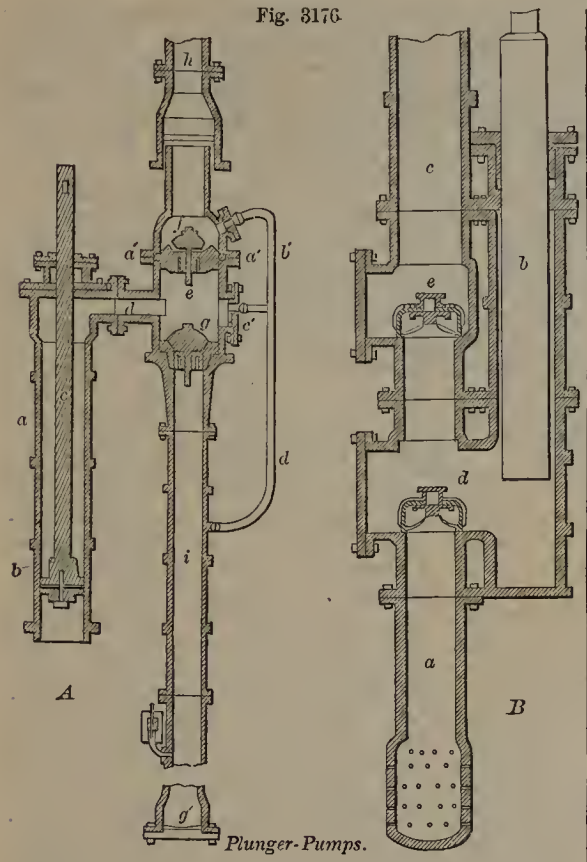
The illustration is from Combe's work on mines, and represents a pump erected by Juncker at Huelgoat. It raises water to a hight of 508 feet, and is calculated to raise it a farther distance of 246 feet when the mine reaches that depth.

The small pipe *b'–c' d* is provided with stop-cocks, and is for the purpose of establishing communication between the pipes *h i* and the valve-chamber *e* in starting the pump.

A small side-valve is fitted to the descending pipe *i*, and loaded with a weight equal to about the pressure of the atmosphere. This valve is placed just above the surface of water in the well, and if the valve *g* does not shut properly, the pressure of the water which is raised during the up-stroke of the piston is transmitted to that contained in the descending pipe and causes the small valve to open.

By means of this, also, it can be ascertained if the upper valve *f* closes properly. For this purpose, the pump must be stopped and the valve-chest put in

Fig. 3176.

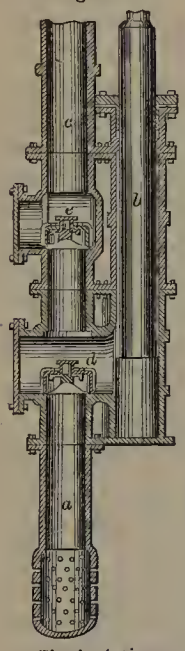


Plunger-Pumps.

communication with the descending pipe, by opening the stop-cocks in the small pipe *c' d*. Then, if the valve *f* closes imperfectly, the water from *h* will come through it and fill the descending pipe *i*, raising the small valve. This effect will, of course, not take place unless the foot-valve *g'* is in order, — a fact which can be readily ascertained.

B (Fig. 3176) is a section of a force-pump, with solid plunger-piston, such as is commonly used for raising water from mines, rivers, and wells. *a* is the suction-pipe, *b* is the solid plunger-piston, shown near the bottom of its stroke, *c* is the ascending pipe going to the top of the well, *d* is the lower valve-chest, and *e* the upper valve-chest. The valves are double beat. When *c* is open in consequence of the descent of the piston having forced up the water and raised it into that position, the same pressure closes the valve *d*, which then sustains the whole pressure of the column in *c*. See Fig. 3177.

Fig. 3177.



Single-Acting Plunger-Pump.

The plunger is raised by the pressure of the steam on the piston in the steam-cylinder; and as the cover of the pump-barrel through which it works is perfectly air-tight, no air can pass in from the outside to supply its place. A partial vacuum is therefore formed, which is supplied by the air beneath the lower valve and between this and the water. After each stroke this air becomes more and more rare, and the vacuum more and more perfect; till at length the water in the well, pressed by the atmosphere outside, follows the ascent of the piston, and rises through the foot-valve into the pump-barrel. When this is full of water, the plunger descends and presses on the water, which can neither go back through the lower valve nor escape through the cover of the pump-barrel. It can only escape through the valve of the ascending pipe, each successive stroke of the plunger sending into the ascending pipe a quantity of water equal to the volume of the plunger. This goes on till the ascending pipe is full, and then, at each stroke, it delivers a quantity equal to the volume of the plunger.

Min'ing-tools. *a b c d e f g*, forms of miner's picks.

h i j, miner's hammers. *k l*, long picks. *m n o*, miner's wedges. *p*, sharp-point shovel. *q*, square-point shovel. *r*, *bulling*-shovel for dressing ores. *s*, Spanish hoe. *t*, sledge for breaking ores. *u*, mallet for striking borers (*y z*). *v*, pick for driving gad. *w*, steel gad for wedging off pieces of stone. *x*, cobbing-hammer, used in the mines for breaking ore. *y z*, borers for jumping holes to receive blasting-charge.

Fig. 3178.

Mining-Tools.

Min'ion. 1. (*Printing.*) A size of type between Nonpareil and Brevier.

Nonpareil, 148 ems to the foot.
Minion, 123 ems to the foot.
Brevier, 112 ems to the foot.

2. (*Ordnance.*) An old 4-pounder gun, about 7 feet long.

Min-ion-ette'. A small fancy type.

Min'i-um. Red lead.

Mint. A place where bullion is made into coin. See COINING.

Mint'age. Duty paid for coining.

Mint'ing-mill. A *coining*-machine. See COINING.

Min'ute. 1. The sixtieth part of an hour.

2. The sixtieth part of a degree.

3. The sixtieth part of the lower diameter of the shaft of a column.

Min'ute-glass. The sand-glass running sixty seconds. *Half*-minute and *quarter*-minute glasses are used at *heaving the log.*

Min'ute-hand. The hand pointing to minutes on the dial of a clock or watch, and traversing the circle in one hour.

Min'ute-jack. (*Horology.*) A fanciful little figure in some clocks which strikes the gong at the prescribed times.

Min'ute-wheel. (*Horology.*) One of the wheels placed between the pillar-plate of a watch and the dial. Also called a *dial-wheel.*

Mir'ror. Mirrors are mentioned in the Book of Job (chap. xxxvii. verse 18), and Moses relates that the brazen laver or washing-basin was made from the mirrors of the women who assembled at the door of the tabernacle of the congregation (Exodus, chap. xxxviii. verse 8).

The ancients had drinking-vessels, the insides of which were cut into mirrors so disposed that the image of the person drinking from them was seen multiplied. A weighty silver cup of this description was presented to the Emperor Probus, when a tribune, by Valerian.

The mirrors of Egypt were of bronze, which, in certain proportions of copper and tin, is called by Ure the whitest, hardest, most brilliant and refractory of metals. See *speculum-metal* in ALLOYS.

A number of the Egyptian mirrors are preserved in the British Museum. They are from 5 to 14 inches in dimensions. They are generally furnished with handles, carved into ornamental or symbolic forms; resembling a tress of hair, a hawk's head, a column, a lotus scepter, or the goddess Athor. Several specimens may be seen in Abbott's collection in the possession of the New York Historical Society.

The mirror with a handle is emblematical of Venus, and is represented on the stones in the ruins of Al Hadhr on the Tigris, the Atra of Ammianus Marcellinus.

Silver mirrors were introduced by Praxitelès, 328 B. C.

A famous mirror of antiquity was that placed by Ptolemy Euergetes (247 B. C.) on the summit of the Pharos of Alexandria. The clearness with which distant objects were depicted caused observers to speak of it in exalted terms beyond any reasonable belief. Abulfeda, the geographer, who wrote 1,000 years subsequently, states that it was made of "Chinese iron," which Buffon supposes was steel, but was more probably one of the white alloys for which China was and is so famous. Probably nearly allied to speculum-metal.

The ancients knew, —

1. That the rays of light were projected in straight lines.

2. That the angle of incidence is equal to the angle of reflection.

These were their only contributions to the science of optics.

Alhazen, about A. D. 1100, shed a flood of light on the subject.

Silver is the most powerful reflector, absorbing but 9 per cent of the light (speculum-metal absorbs 37 per cent of the rays), and for this reason, as well as its durability, was largely employed by the ancients for making mirrors. Silver mirrors are enumerated in the Roman laws among other articles of plate; and Pliny, Seneca, and other writers who ridicule the extravagance of the times, tell us that every young woman of that period must have a silver mirror. These mirrors, judging from the specimens in collections of antiquities, were merely faced with a thin sheet of the precious metal.

Pliny speaks of mirrors composed of a mixture of copper and tin, and says that the best were constructed at Brundisium. A composition of copper, regulus of antimony, and lead, the first largely predominating, was also employed. Such stones as were capable of receiving a brilliant polish and reflecting a large proportion of the rays of light were sometimes made use of.

Mirrors of stone were found among the Peruvians when first visited by the Spaniards. Some of these were made of a black, somewhat transparent, vitrified lava, called by the Spaniards *gallinazo*, similar to the obsidian stone employed by the Romans for the like purpose. These mirrors were plane, concave, and convex. The Peruvians also made them of a species of pyrites called the Inca's stone, from its being much used in ornaments by the Incas or princes of Peru. Ulloa saw one which was $2\frac{1}{2}$ feet in diameter; but they did not usually exceed 2 to 3 inches. This people had also, it would appear from De la Vega, mirrors of silver, copper, and brass.

The date of the invention of glass mirrors is not certainly known. From the account of Pliny, it would seem that they had been formerly made at the celebrated glass-houses of Sidon. These were probably of a dark-colored glass, having a resemblance to the obsidian stone. Transparent glass having a backing of black foil has also been found. The former of these kinds was inferior to metallic mirrors and was probably superseded by them. From the time of Pliny to the thirteenth century, the subject appears veiled in obscurity, and the first unequivocal mention of glass mirrors similar to those of modern times is by Peckham or Peccam, an English Franciscan monk, who, in a treatise on optics, written about the year 1279, speaks of mirrors of iron, steel, polished marble, and of glass covered on the back with lead, and says that no image was reflected when the lead was scraped off. Roger Bacon and others of that age also make mention of this description of mirror. The process of manufacture was by pouring molten lead or tin on the back of the glass plate.

The method of coating with tin-foil was known as early as the sixteenth century, and at Murano, where it was first practiced, the process was as follows: The tin, hammered into thin leaves, was spread out very smoothly: the quicksilver was poured over it and rubbed into it, either with the hand or a hare's foot; and when the tin was saturated it was covered with paper. The glass, wiped very clean, was then laid above it, and while the workman pressed it down with his left hand, he drew out very carefully with his right the paper between the tin and glass, over which weights were afterward placed.

The Venetians had for a long time a monopoly of the business, and till about the end of the seventeenth century their glasses were met with all over Europe and both the Indies. After that period, the improvements in glass-making in other countries, particularly in France, where it was discovered that glass could be cast into much larger plates than had been before prepared by blowing and rolling, destroyed the ancient supremacy of Venice in this art. An unsuccessful attempt was made in France as early as 1634 to establish glass-houses for manufacturing mirrors, and in 1665 Nicholas de Mayer

obtained a patent from the French government, and proceeded to erect works for the purpose. This patent was in 1684 renewed for thirty years, but in 1688 Abraham Thevart succeeded in casting at Paris plates of a size which astonished all who saw them; they were 84 inches long and 50 broad, while the largest of those previously made had not exceeded 45 or 50 inches in length.

Among the more remarkable modern mirrors may be cited several of from 20 to 36 inches diameter. One made by Villette was tested by Drs. Desaguliers and Harris. It was composed of an alloy of tin, copper, and bismuth. It was 47 inches in diameter, and was ground to a sphere of 76 inches radius. Its effects were as follows: —

Tin was melted in	3 seconds.
Cast-iron	16 "
A silver sixpence	7 "
A half-penny of George III.	34 "
Slate	3 "
Granite vitrified	54 "
Copper ore	8 "
Boue, calcined	4 "

Tschirnhausen's mirror was 4½ French feet in diameter; its focus, 12 feet.

It vitrified pumice, slate, tiles, shells, pieces of crucibles; lighted green wood instantly, and dissolved an alloy of lead and tin like so much lard.

Newton's mirror had 7 concave glasses, each 11½ inches in diameter; one in the center, the others encircling it, so as to have a common focus. The diameter was 34½ inches, the focus 22½ inches distant. It vitrified brick in 1 second, and melted gold in 30 seconds.

Zeicher formed his mirrors by pressing disks on a hot convex former, to give them their curvature.

Buffon constructed a combination of 140 plane mirrors, each 4 × 3 inches, on a wooden frame 6 feet square. Three set screws to each mirror gave perfect adjustability, and the result was a vindication of the probability of the statement in regard to Archimedes. With but 24 of the mirrors in focus, he lit pitch and tow at a distance of 66 French feet. By a subsequent arrangement of 168 pieces of plane looking-glass, 6 inches square, he lit beech-wood at 150 feet distance and melted a silver plate at 60 feet.

His final attempts were with a frame of 360 plane mirrors, 8 × 6 inches; and one of 400 mirrors, 6 × 6 inches. Wood was kindled at 210 feet distance, tin melted at 160 feet. See BURNING-GLASS.

Petijean's patent (1856) is for a process of silvering by the use of a compound formed of nitrate of silver, ammonia, and tartaric acid. The solution is applied to a polished glass, and silver is precipitated to the amount of about one pennyweight to each square foot of glass. It is then protected by a dark varnish.

Walker (1869) uses the same ingredients in somewhat different proportions. The surface of the glass is thoroughly polished with whiting and washed with distilled water, when the plate is heated to about 120°, and the solution applied. After the silver is precipitated and dried, the plate is varnished with shellac, and then painted with a compound of red lead and litharge to protect the coating of silver. See SILVERING; PLATINIZING; LOOKING-GLASS.

Mi'ser. A large auger for excavating earth in wet situations, as in sinking holes for pier foundations. It is of cylindrical form, has a protruding lip, to enable it to scrape up the soil as it is rotated, and is lifted to the surface to discharge its load.

Mis-e-re're. A projecting bracket in the under side of the seat of a church stall. It is often more or less ornamented with carvings of leaves and grotesque subjects.

Mis-pick'el. An ore of arsenic combined with iron.

Mi'ter. A joint where two pieces are framed together, matched, and united upon a line bisecting the angle of junction.

The term forms a part of several compound words which follow here.

Mi'ter-block. (*Joinery.*) One arranged for sawing pieces to an angle of 45°.

Mi'ter-box. 1. (*Printing.*) A box in which rules are placed while the ends are cut obliquely, so as to make a miter-joint with another rule.

2. (*Carpentry.*) A trough with vertical kerfs, which intersect the sides at an angle of 45°, to form guides for a saw in sawing the ends of pieces to make miter-joints.

Mi'ter-dove'tail. (*Joinery.*) A form of concealed dovetail which presents only a single joint line, and that on the angle. See DOVETAIL.

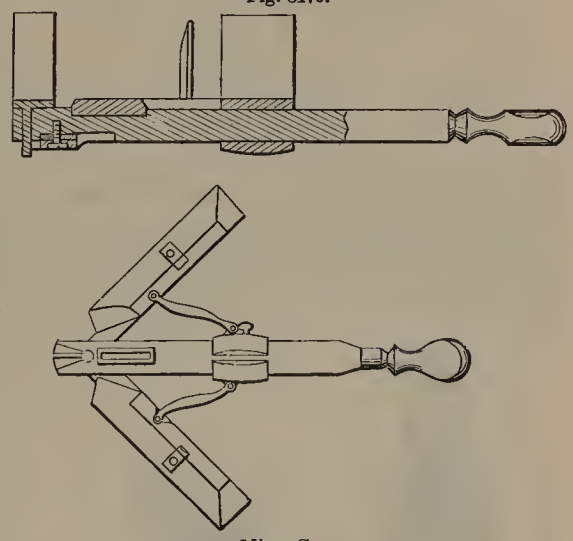
Mi'ter-drain. The transverse drain in the metaling of a road.

Mi'tered. (*Bookbinding.*) Said of fillet ornamentation when the lines unite exactly at their junction without overrunning.

Mi'tered Bor'der. The edging around the slabstone of a hearth.

Mi'ter-gage. A gage to determine the angle of a miter-joint in picture-frames, moldings, etc. Fig. 3179 shows such a gage, having a pair of arms hinged to a stock, on which is a sliding clamp that

Fig. 3179.



Miter Gage.

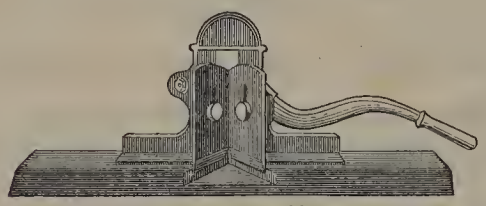
carries the saw-guide, which is connected by links with the said arms, so as to allow them to be placed within and conform to any angle, and insure at the same time the proper position of the stock midway between the said arms.

Mi'ter-ing-ma-chine'. 1. (*Printing.*) A machine for mitering printers' rules, so that their ends may meet at a miter-joint. Various adjustments are found in the United States patents.

McDonald, July 3, 1855
Grover and Pelouse, May 29, 1860.
Babcock, February 5, 1861.
Walker, December 3, 1867.
Ustich, July 21, 1868.

2. (*Joinery.*) A machine for mitering or slanting the ends of pieces which are to be united by a miter-joint. The machine illustrated is adapted for mitering frame moldings, panel moldings, etc. The irons

Fig. 3180.



Mitering-Machine.

work at right angles to one another, and cut the miters true and clean.

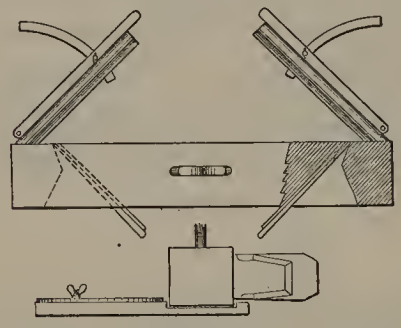
Mi'ter-i'ron. (*Forging.*) A number of bars of angular shape wedged together inside a hoop to form a fagot for a large forging.

Mi'ter-joint. A joint formed by the meeting of matching pieces in a frame, the parts uniting on a line bisecting the angle, which is usually 90°, but not necessarily. See *b e*, Fig. 3182.

Mi'ter-plane. (*Joinery.*) *a.* A plane whose bit is set obliquely across the face of the stock, so as to make a *draw*-cut.

b. A plane running in a race bearing a certain angular relation to the fences or gages which hold and present the stuff.

Fig. 3181.



Miter-Plane.

In the example, the plane works in a groove of the frame and has a cutter at each end. Pivoted adjustable guides hold the stuff at any required angle.

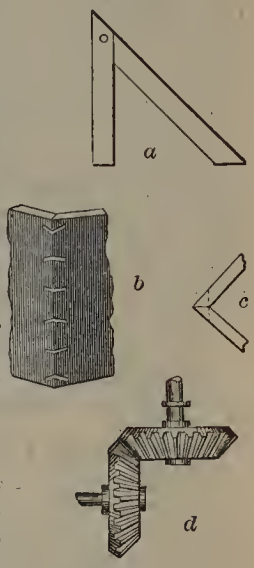
Mi'ter-post. (*Hydraulic Engineering.*) The outer vertical edge of a canal-lock gate, obliquely chamfered to fit against a similar surface on the companion gate.

Mi'ter-sill. (*Hydraulic Engineering.*) A raised step on the floor of a *lock-bay* against which the feet of the lock-gates shut. (See CANAL-LOCK.) The *head miter-sill* for the *head-gates*, and the *tail miter-sill* for the *tail-gates*.

Mi'ter-square. A *bevel-square* whose blades are set immovably at an angle of 45° with each other. The term is used somewhat loosely to denote a square whose blade is adjustable to any angle. A *bevel*.

Mi'ter-valve. A valve whose rim forms with the face of the seat a miter-joint; an angle of 45° with the axis of the valve-disk. See PUPPET-VALVE.

Fig. 3182.



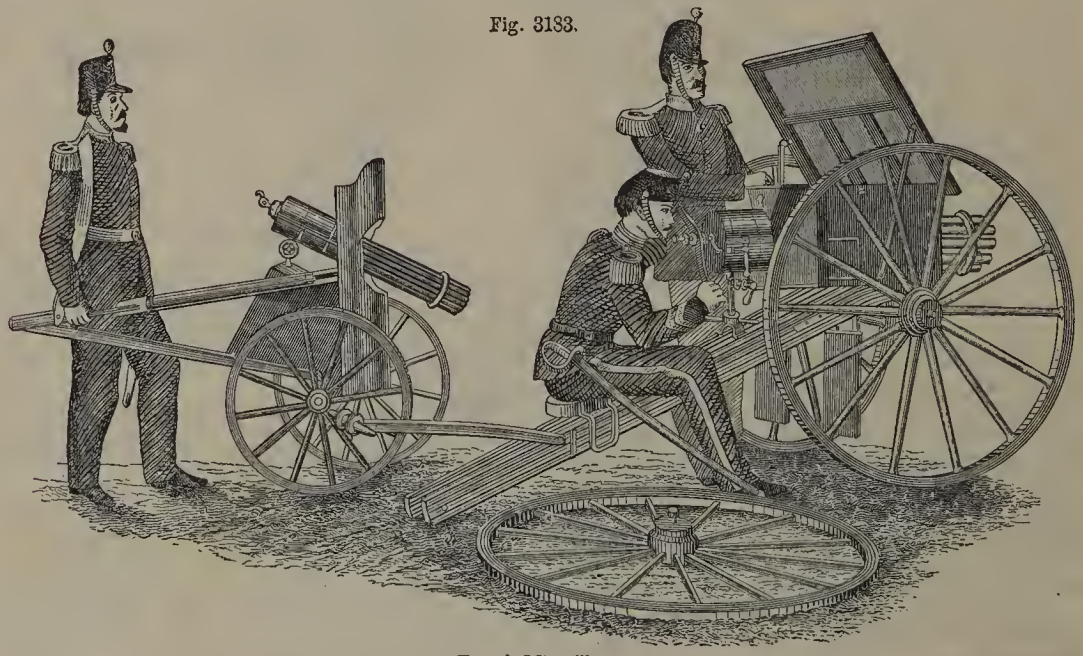
Miters.

Mi'ter-wheel. One of two bevel wheels of equal diameter, and whose working-faces have an equal obliquity to their axes, usually 45°. See *d*, Fig. 3182.

Mi'trail-leur'. (*Fire-arms.*) A French form of battery-gun which is loaded at the breech, by a block containing pockets for a number of cartridges. These are fired consecutively or in a volley. Charged plates are kept in reserve.

The object is to obtain greater accuracy and range than are attainable by the case or canister shot, discharged from cannon. These are contained in an envelope which is ruptured either by a bursting charge within or by the force of projection, and have consequently a tendency to scatter over a considerable area. The mitrailleur, or machine-gun, on the contrary, sends a large number of small projectiles independently, and with precision, to a considerable distance.

Fig. 3183.



French Mitrailleur.

The infernal machine with which Fieschi attempted to assassinate Louis Philippe in 1835, and succeeded in killing eighteen persons, including Marshal Mortier, and wounding a large number of others, besides severely injuring himself, was one of the earliest attempts with which we are acquainted for producing a simultaneous discharge from a number of gun-barrels. These were arranged side by side on a bench or stand, and fired by a train, much as in the mode of firing barrels in a proving-house.

That first tried in the French service was made by removing part of the breech from a brass field-piece and inserting twenty-five rifle-barrels, open at both ends, into the bore; these extended back, so that their rear ends were flush with the face of that part of the breech in front of the opening, into which was inserted a case having a number of cylindrical openings equal to that of the barrels, and filled with cartridges; from these, by means of an equal number of plungers operated by a hand-screw, the cartridges were forced into the barrels; the charging-case was then removed, and replaced by a firing-block provided with a lock and pin for each cartridge, by which they were successively fired on turning a cylinder in the firing-block.

A later form of the weapon is shown in Fig. 3183. It has 37 barrels, and ammunition-chests alongside the gun on the same axle. The 37 cartridges, intended for one charge, are contained in a small box. A steel plate with corresponding holes is placed on the open box, which is then reversed, and the cartridges fall points foremost into their respective holes. They are prevented from falling through by the rims at their bases. The loaded plate is then introduced into the breech-slot, and when the breech is closed by a lever, a number of steel pins, pressed by spiral springs, are only prevented from striking the percussion arrangement in the cartridges by a plate in front of them. When this case is moved slowly by a handle, the cartridges are fired one by one. If the plate be withdrawn rapidly, they follow each other so quickly that their discharge is all but simultaneous.

The projectile weighs 37 grammes, or a little over an ounce. The charge of powder is from 6 to 8 grammes. The last amount is that counseled by the inventors.

The mitrailleur of 37 barrels weighs 180 kilogrammes, or 400 pounds, without the carriage, and can be worked by two men. It was found, however, at Vienna, in December, 1869, that to obtain the most rapid firing, or 481 balls per minute, five men were necessary to work the piece.

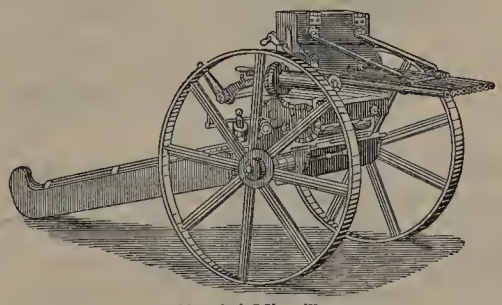
The front carriage contains from 48 to 56 boxes for loading, and the two caissons hold 16 breech-plates furnished with cartridges. The mitrailleur is, therefore, provided with 2,368 cartridges; and a battery of 8 mitrailleurs can hurl on an attacking column 3,848 effective projectiles per minute.

Another form of battery-gun employed by the French in the war with Germany consists of a series of barrels arranged side by side, the muzzles slightly diverging, and loaded at the breech by means of a rectangular breech-block containing two rows of chambers, one above the other. The cartridges are inserted into the upper row of chambers; the breech-block, which turns on an axis, is partially revolved, bringing the loaded chambers in line with the barrels, and the machine is fired, while at the same time the empty row of chambers is loaded; and these operations are repeated continuously. The machine was intended principally for defending the flanks of a column or line, or the angles of a square. It has no carriage, but is mounted upon a light frame of iron, with a pair of hinged legs in front and another in rear, which are locked in position for firing by a hinged brace, and which serve as handles for transporting it from place to place, two men performing this operation.

The Billinghurst and Requa battery, an American invention, consisting of 24 rifle-barrels arranged on an axle, and capable of parallel or diverging fire, was in use in the United States service in 1861.

The Abbertini, one of the forms of this weapon in use in Europe, has ten barrels similarly arranged; the working of the machine being performed by a crank which, through intermediate devices, conveys the cartridges to the barrels from the box-like magazine at the rear of the barrels upon the mounted frame or carriage. The barrels, after each discharge, are

Fig. 3184.



Abbertini Mitrailleur.

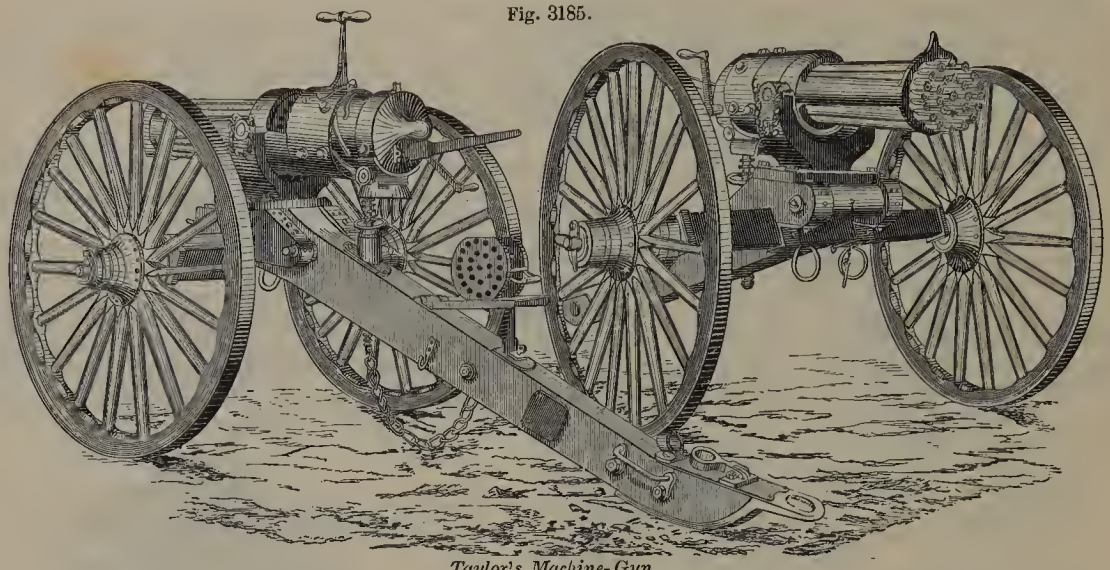
cleaned by special appliances; the entire number of barrels can be discharged from eighteen to twenty times a minute.

Hotchkiss's mitrailleur is a bundle of rifled cannon, throwing explosive shells weighing 23½ ounces at the rate of 60 in 48 seconds. It is mounted and rotated like the Gatling gun, but the loading and firing apparatus differ from the latter. It has been tried experimentally in France and Italy.

Taylor's machine-gun is shown at Fig. 3185.

The charging-blocks, one of which is shown on the shelf on the trail of the gun, are filled with cartridges automatically from a magazine carried in the caisson, the magazine having chambers corresponding with those in the charging-block, and containing springs to press the cartridges forward. The rear view shows the gun open to receive the charge. The handle, seen in a vertical position, is attached rigidly to a sleeve, which has a concentric reciprocating movement of about 90°, and imparts a longitudinal movement to the breech-block and cascabel by means of studs projecting from the interior of the sleeve into spiral grooves in the sliding breech. The charge-block being inserted, the handle is drawn down into horizontal position. The rotation thus imparted to the sleeve closes the breech-chamber, slides the breech forward, pressing and locking the block firmly against the rear of the barrels, and, by means of plungers projecting from the front of the breech, forcing the cartridges partially through the block and into the barrels. The front view shows the arm with its breech closed in readiness for firing. The discharge may be effected simultaneously in all of the barrels by depressing the longitudinal lever which projects backward from the breech, and carries a pawl adapted to catch and suddenly release a sliding hammer concealed within the cascabel. The hammer is then driven forward by springs, striking all the firing-pins at once. The barrels can be discharged in succession by means of the crank shown at the side of the breech. This crank rotates a tappet or cam-wheel arranged to retract and release all the firing-pins in succession. The barrels are arranged

Fig. 3185.



Taylor's Machine-Gun.

in concentric circles at back, but diverge slightly forward so as to spread the fire in a horizontal plane.

The empty cartridge-shells are held by the charge-block and withdrawn with it.

Mit'ten. A hand covering, with one cell for the thumb and another which contains all the fingers.

It is a common and evident plan with clumsy manufacturers or material, or for the warmth of association of the fingers, to give the latter a common compartment and a special pocket for the thumb. Abbé Huc found the Tartarian gloves thus made. As a Frenchman, he was surprised; but these fellows had not been battling with winds fresh from Siberia for so long to no purpose.

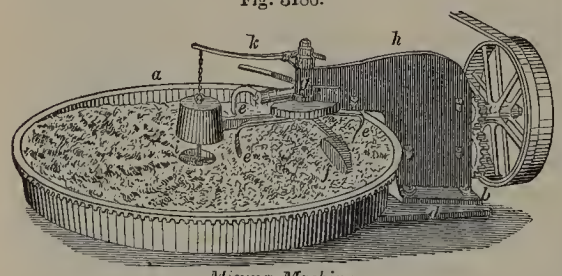
Mixed Fab'rics. Those in which two or more fibers are combined. The varieties are numerous; such as *tweeds*, *poplins*, *cassinets*, etc.

Mix'ing. 1. (*Cloth.*) Uniting wool of different colors for *mixed cloth*, called *medleys*.

2. Intimately compounding ingredients by stirring together, or passing together through sieves.

Mix'ing-ma-chine'. Poole's machine for mixing chemicals, fertilizers, etc., consists of a pan *a*, the upper edge of which is flanged, constituting a circular toothed rack, engaged by a gear-wheel on

Fig. 3186.



Mixing-Machine.

the same shaft with the wheel *b*, and turned by a wheel *c* on the driving-pulley shaft. A circular projection on the bottom of the pan fits a groove on the base-plate *d*, serving to steady the pan during its rotation; this may contain a lubricant. The stirrers or rubbers *e e* and scraper *f* are attached to an upright shaft, turned within the sleeve *g* on the arm *h* by bevel gears on it and on the pulley shaft. By this means they are constantly rotated during the revolution of the pan. When a charge of material is thus thoroughly mixed, the plug *i* is removed by lifting the lever *k*, when the material, guided by the scraper, passes through the central aperture into a discharge-pipe, or a vessel prepared to receive it.

Mix'ing-sieve. One by which ingredients are intimately combined by sifting together.

Miz'zen. (*Nautical.*) The aftermost mast in a three-masted ship, or in those two-masted ships in which the forward mast is the larger; such as the *ketch* and *yawl*.

The *main* is always the larger mast. When the larger mast in a two-masted vessel is forward, the one abaft is the *mizzen;* when the larger mast is abaft, the one nearer the bows is the *fore*-mast.

The word *mizzen* indicates the relation of many parts, as *mizzen-top, mizzen-shrouds, mizzen-rigging*, etc.

The *bonaventure mizzen* is a second or additional mizzen-mast employed in some ships with four masts.

Moat. (*Fortification.*) A ditch around a rampart.

Moc'ca-sin. A deer-skin sandal, the sole and upper of which are formed of one piece of leather.

The Indian process is as follows: The skin is stretched and dried. The brains are dried in the sun. The skins are soaked, hair removed by a knife, placed with the brains in a pot and heated to about 100°. The skins are taken out, wrung, stretched with lines and pegs, and persistently rubbed with a hard stone to soften them. Among some tribes the leather is softened by mastication. The squaws of course do the chewing. See PAC.

Mock Gold. A yellow alloy. Factitious gold.

	Copper.	Platinum.	Magnesia.	Zinc.	Tin.	Borax.	Sal-ammonia.	Saltpeter.	Lime.	Tartar.	Putty.
Hermstadt's (resembles gold in color and specific gravity)	7	16		1							
Hackert's patent	16			2		2		2		16	2
Hamilton and Parker's	32			33							
Pinchbeck	4			2							
Manheim gold	16			4	1						
Red tombac	11			1							
Ormolu	48			52							
Prince's metal	2			1							
New formula	100		6		17		3.6		1.6	9	

See also JEWELERS' ALLOYS, page 63.

Mock Plat'i-num. Brass, 8; zinc, 5.

Mock Sil'ver. A white-metal alloy for jewelers.

	Copper.	Tin.	Bismuth.	Platinum.	Silver.	Nickel.	Zinc.	Antimony.	Lead.	Steel.	Aluminium.
Von Eckart's (same gravity as silver)	11.71			2.4	3.53						
Packfong or tutenag	40.4					31.6	25.4				
White tombac	16	1									
Tonca's patent	5	1				4	1				
Tutania, German	1	48						4			
Tutania, Spanish		28						2		1	
Queen's metal		9	1	Cadmium.				1	1		
Queen's metal	4	100	1					8			
Parisian white metal	69.8			4.7		19.8	5.5				
German white copper	83					8.75		1			
Minargent	100					70				Tungsten. 5	1

See also ALBATA; BRITANNIA-METAL; PEWTER; BIDDERY-WARE; POT-METAL; SPECULUM-METAL; and tables, pages 62 – 65.

We read of one copper alloy in Strabo, called by him a mock silver (*Pseud argyrum*). It is not clear whether the stone which was added to the copper was an ore of nickel or some other white metal. He calls the alloy *oreichalcum*. Brass and bronze were well known to him, and this alloy was of a white color.

Mod'el. 1. A pattern, usually on a diminutive scale, of a work which has been or is to be done.

Working-models are diminutive machines, with all the parts capable of performing work on a scale proportioned to their size.

The best and largest collection of mechanical models in any country or time is that in the United States Patent Office, where, since 1836, have been deposited the models accompanying about 200,000 applications for patents, excepting in that small proportion of the inventions consisting of processes and compounds in which no model is required. The model saloon occupies the whole upper floor, a circuit of 2,000 feet, the cases being arranged on both sides of the four long halls encircling the building. The cases are in double tiers with galleries.

Ingenious mechanics in all ages of the world have devoted much time and skill to the manufacture of minute mechanical devices. "In the twentieth year of Queen Elizabeth, a blacksmith named Mark Scaliot made a lock, consisting of eleven pieces of iron, steel, and brass, all of which, together with a key to it, weighed but one grain of gold. He also made a chain of gold, consisting of forty-three links, and having fastened this to the before-mentioned lock and key, he put the chain about the neck of a flea, which drew them all with ease. All these together, lock and key, chain and flea, weighed only one grain and a half.

"Oswaldus Norhingerus, who was more famous even than Scaliot for his minute contrivances, is said to have made sixteen hundred dishes of turned ivory, all perfect and complete in every part, yet so small, thin, and slender that all of them were included at once in a cup turned out of a peppercorn of the common size. Johannes Shad of Mitelbranch carried this wonderful work with him to Rome, and showed it to Pope Paul V., who saw and counted them all by the help of a pair of spectacles. They were so little as to be almost invisible to the eye.

"Johannes Ferrarius, a Jesuit, had in his possession cannons of wood, with their carriages, wheels, and all other military furniture, all of which were also contained in a peppercorn of the ordinary size.

"An artist named Claudius Gallus made for Hippolytus d'Este, Cardinal of Ferrara, representations of sundry birds sitting on the tops of trees, which, by hydraulic art and secret conveyance of water through the trunks and branches of the trees, were made to sing and clap their wings; but at the sudden appearance of an owl out of a bush of the same artifice, they immediately became all mute and silent." — *World of Wonder.*

Boverick, the French artificer, made a chain of two hundred links, with its padlock and key, all weighing together less than the third part of a grain. He was also the maker of a landeau, which opened and shut by springs. This miniature equipage, with six horses attached to it, a coachman seated on the box, with a dog between his legs, four inside and four outside passengers, a postilion riding one of the four horses, was drawn with all the ease and safety imaginable by a flea.

A writer in the "Gentleman's Magazine" gives the following account of a visit to the model-making workshop of Thomas Smith, on the Surry side of the river Thames, near Lambeth Palace, London.

"Beginning with the larger of his productions, the first object to which he directs our attention is a small steam-pumping engine for working a table fountain. All the adjuncts that pertain to a great pumping-engine are to be found in this diminutive model. There was even the gage glass on the front of the boiler, as slender as a good-sized needle, and fitted with taps at each end, in the nozzles of which a pin could hardly be inserted. The whole thing worked to perfection, without rattling or any escape of steam from the engine or water from the pumps, and will throw a small jet of water in a distant part of the room to a hight of twelve feet.

"At the time of our visit a number of diminutive garden-pumps, small enough to be carried in the waistcoat-pocket, are scattered over the work-benches in various stages of completion. These are for the use of agents and commercial travelers trading with such articles. But the above-described curiosities are huge compared with those next set before us. We are introduced to a model of the famous 'Great Britain,' made to a scale of $\frac{1}{40}$ of an inch to the foot, so that the length of the model is about 8 inches, and the breadth about $1\frac{1}{4}$ inch. It is full-rigged, with six masts and their accompanying spars, and all the hatchways and deck fittings. The deck of this tiny vessel is lifted off and a magnifier is handed to us; this resolves a little heap of metal scraps into an accurate model of the original engines with which the 'Great Britain' was fitted. So small is this model that it stands upon less space than the area of a shilling. An annular trough of water is produced, and the ship is launched into the watery circuit. A tap is turned, and compressed air rushes through a tube, and off goes the tiny ship to circumnavigate its little sea. The total weight of the boat, with deck and rigging, engines, boiler, and all entire, is less than a troy ounce! The actual weight of the working part of the engines — that is, all excepting the boiler — is just that of a sovereign."

One of the tiniest working models in the world is now in the possession of John Penn (of Greenwich), the eminent maker of the great engines of which it is the reduced counterpart. It will stand on an English silver 3*d.* piece; it really covers less space, for its base-plate measures only $\frac{3}{8}$ of an inch by about $\frac{3}{10}$. The engines are of the trunk form introduced by Penn; the cylinders measure $\frac{1}{8}$ of an inch in diameter, and the trunk $\frac{1}{20}$. The length of stroke is $\frac{3}{40}$ of an inch. They are fitted with reversing gear, and are generally similar in design to the great machines with which ships of the "Warrior" class are equipped. From the extreme smallness of this model a few minutiæ — such, for instance, as

the air-pumps — have necessarily been omitted; so small are some of the parts, that they require a powerful magnifying-glass to see their form. The screws which hold the members together are only $\frac{1}{80}$ of an inch in diameter, and these are all duly furnished with hexagonal nuts, which can be loosened and tightened by a Liliputian spanner. The whole weight of the model is less than a threepenny-piece.

A steam-pump, consisting of a steam and water cylinder, made by Charles Fichtel of Philadelphia, in 1860, was auxiliary to a model of a steam fire-engine. The steam-cylinder was $\frac{1}{8}$ of an inch in diameter, and the whole affair would go into a common thimble.

2. (*Plastic Art.*) The invention of the art of modeling in clay is attributed to Dibutades the Corinthian, about 985 B. C. His daughter traced the profile of her lover, by his shadow on the wall; and her father filled up the outline with clay, which he afterwards baked. Had Pliny known more of Egypt and Phœnicia he might have made a better statement. Pots and lamps had been made in rude resemblance of faces and figures for unknown ages past. Etruria, from which Rome received her agriculture, fine arts, armor, metal-working, astronomy, navigation, measurements, coins, weights, furniture, dress, habits, and medicines, was also her mistress in the ceramic art. Geodetical models, in which the contour of the earth is shown in relief, are among the most interesting of all geographical representations. The mountains of Switzerland were modeled in miniature, by General Pfiffer. In modeling a tract of country, it is usual, as in plotting a profile of a route, to exaggerate the hights to make them more observable. With such vast precipices and eminences as Switzerland affords, the necessity for vertical exaggeration is not so great; but it is apparent that in a modeled map of a country 200 miles square, having no elevation exceeding 1,760 feet, a rise of $\frac{1}{3}$ of an inch on a surface 16 feet square (one inch to the mile) would not be readily seen. The insignificance of the elevations on the earth's crust, compared with the area of the surface, is not generally appreciated, and it is common in plotting profiles of routes as in modeling the superficies, to give the rises and elevations ten times their actual proportion. This is to render them more visible. The largest attempt at geographical modeling was by Mr. Wyld, in his globe erected in Leicester Square, London, 1851–53. (See GLOBE.) The *interior* surface (for convenience of general view) was modeled to represent the chains of mountains, table-lands, river valleys and depressions. It was executed in sections, and castings therefrom were afterward associated on the interior of a vast shell, and painted.

Models of towns and ancient buildings in wood, plaster, and cork have excited much attention and interest, and are common in museums.

Mod'el-ing-board. A board used in loam-molding to give shape to the mold.

Mod'el-ing-plane. A short plane used in planing rounding surfaces. It has a length of from 1 to 5 inches, a width of from $\frac{1}{4}$ to 2 inches. The irons are from $\frac{3}{16}$ to $1\frac{1}{2}$ inches wide.

Mod'er-a'tor. (*Optics.*) A device, known as Rainey's, consisting of an opal glass or ground glass to moderate and diffuse the light passing from a lamp to an object on the stand of the microscope.

Mo-dil'lion. (*Architecture.*) *a.* An ornamental console beneath the corona in some orders.

b. One of the large flowers in a soffit or coved ceiling.

Mod'ule. 1. A measure of proportion. See MODULUS.

2. The lower diameter of the shaft of a column.

Mod'u-lus. In mechanics, a coëfficient of some specified force or property.

"*Modulus of a machine*, a formula expressing the work which a given machine can perform under the conditions involved in its construction. The relation between the work done on a machine by the moving power and that yielded at the working points, either constantly, if its motion be uniform, or in the interval of time which it occupies in passing from any given velocity to the same velocity again, if its motion be variable. Called also the *efficiency* of the machine.

"*Modulus of elasticity*, the measure of the elastic force of any substance, expressed by the ratio of a pressure on a given unit of the substance to the accompanying compression. Or an expression of the force which would be necessary to elongate a prismatic body of a transverse section equal to a given unit, or to compress it within the limits of its elasticity.

"*Modulus of rupture*, the measure of the force necessary to break a given substance." — RANKINE.

Mo'el-lon. Rubble stone filled in between the facing walls of a structure, or between the spandrels of a bridge. It consists of clean, broken stone, and where it holds an important position, as in the latter-mentioned case, it is laid in mortar, and by hardening becomes equal to a solid mass of stone.

Mo'hair. (*Fabric.*) From a Hindoo word. *a.* A fabric made from the fine, white, silky hair of the Angora goat and allied species. Sometimes called *camlet*. The hair is said to be produced in perfect quality in no place excepting Angora in Asia Minor, and has long been a valuable article of export from that place.

b. A wool and cotton goods made in imitation of the above, in mixed colors or plain.

Moiles. The metallic oxide adhering to the glass which is knocked from the end of the blow-pipe.

Moi'neau. (*Fort.*) A small, flat bastion raised in front of an intended fortification, to defend it against attacks by small-arms.

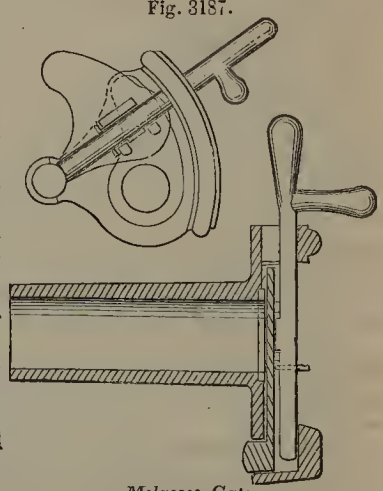
Moire. Watered or clouded silk. The thick silk goods is damped, folded in a peculiar manner, and subjected to great pressure, say, from 60 to 100 tons. "Green watered moyre" is mentioned by Pepys in his Diary, 1660.

Moire An-tique'. (*Fabric.*) A heavy, watered silk.

Moire Met'al-lique'. Tin plate which has been acted on by an acid, so as to display by reflected light the crystalline texture of the tin.

A surface of tinned iron is rinsed in an alkali water, dried, warmed, washed in a solution of nitric and hydrochloric acid, dipped in water, washed, and dried. It is then covered with colored varnish. A film of peculiar crystallization is produced in larger or smaller patterns, according to the mode of applying the acid.

Fig. 3187.



Molasses-Gate.

Mo-las'ses-gate. A faucet with a sliding lip at the discharge end, to cut off the flow positively and prevent drip.

Mold. The ma-

trix in which an object is cast. A templet or shaper by which an object is tested for shape or marked to a shape.

1. (*Founding.*) Molds for casting are of several kinds: —

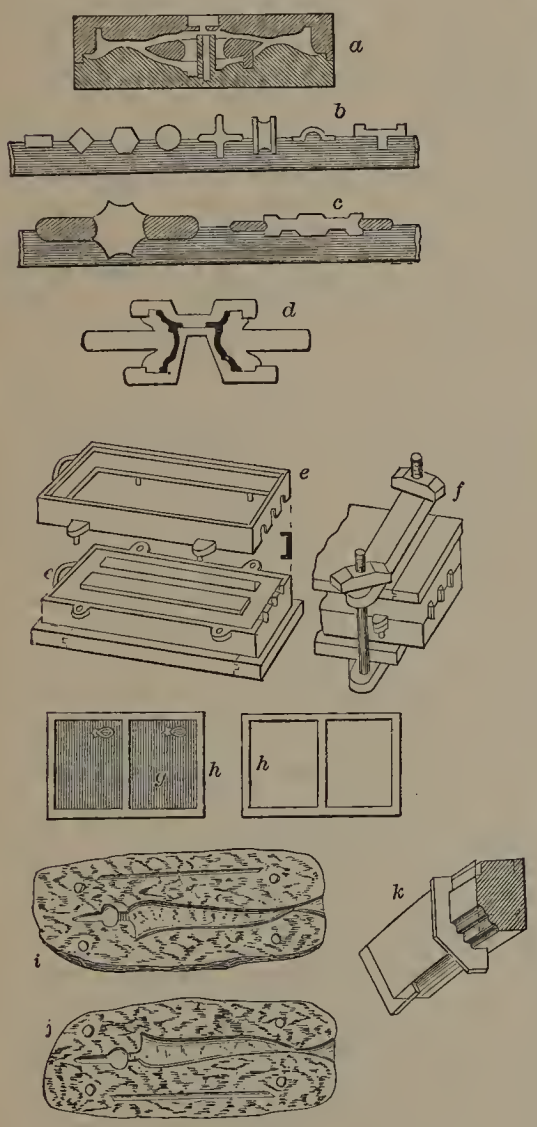
Open molds, into which the metal is poured, the upper surface of the fluid metal assuming the horizontal position. Such are ingots and some other objects.

Close molds of metal or plaster of Paris, with ingates by which the molten metal enters. Such are the molds for inkstands, cannon-balls, bullets, type, and various other articles made of lead, tin, zinc, and their alloys which fuse at a moderate heat.

Close molds of sand, in which articles of iron, brass, bronze, etc., are cast. This is the ordinary foundry work, and includes machinery, stoves, ordnance, and the multitude of articles of domestic and agricultural hardware.

Loam-work casting, in which the mold is built up, instead of being rammed around a pattern, subsequently withdrawn. This is used in casting cylinders, tanks, bells, or ordnance of very large size.

Fig. 3188.



Molds.

For specific index see FOUNDING.

a is a mold of a car-wheel in sand, shown in section.

b is a section showing several small articles partially imbedded in the drag or lower portion of the mold.

c is a view of an article with undercut portions requiring a peculiar treatment by core pieces, which are taken away to remove the pattern, and laid back again before closing the mold.

d is a metallic mold for britannia and pewter ware.

e is a flask, the drag and cope being separated to show the parts. See FLASK.

f shows a portion of the same, with the parts of the flask fastened by a clamp.

i j is an ancient mold for bronze knives, found in the lake of Brienne, and belonging to a period of several thousand years past. It is a gray sandstone of great porosity, and has corresponding holes for the reception of wooden pegs to keep the parts of the mold in place. It is about 12 inches long.

Roman coins were (sometimes) cast in molds, hollowed out in a kind of stone. Molds were also used in making pottery, pastry, cheese, bricks, pisé walls, shoemaker's lasts.

The invention of molds for the casting of wax figures is ascribed to Lysistratus, about 328 B. C.

g h are molds for paper-making.

k is a plasterer's mold for shaping cornice.

The fusibility of metals and alloys is the basis of the founder's art, and furnishes one means by which they are given the varied forms which fit them for application in the arts.

The softer metals and alloys, such as lead, pewter, type-metal, britannia-metal, and even zinc, are usually cast into metallic molds which are used over and over again; but in a more restricted sense molding embraces the formation of molds in sand and loam only, and the filling of such with metals and alloys fusing above a red heat, as cast-iron, brass, gun-metal, bell-metal, etc. In all these cases the mold can be used but once; after pouring and cooling it is broken up to get out the casting, part of its sand only being used again.

The trade of the iron-molder is distinct from that of the brass-molder (who also deals with gun and bell metal), but the methods employed are so nearly identical, that a distinction in describing the several operations is not necessary.

a. Molds are made in *green-sand, dry-sand,* and *loam.* For the first two a *pattern* is required; in the latter it is generally dispensed with.

Patterns are mostly made of wood, although brass and iron are also common, especially when large numbers are required. A pattern always represents the appearance and dimensions of the casting as far as its external surface is concerned. This is also frequently true of its internal surface, but not invariably so, dry-sand *cores* made apart from the pattern being often introduced to form the cavities and internal spaces required. (See CORE.) Patterns are sometimes made in two or more pieces fastened together by pins or dowels, the object being to facilitate their removal from the sand.

The term *green-sand* molding is employed to express the fact that the sand is used pretty much in its *green* or natural state, and is not subjected to any drying or baking process before casting; it is the method followed for the great mass of castings, both iron and brass. The sand for this purpose is kept damp, sufficiently so to ball into a compact mass when squeezed in the hand, but it must not be wet, or approach that condition.

The brass-molder keeps his sand in a molding

trough or bin, over which he works; small castings forming the bulk of his work: but in an iron foundry the whole floor to a considerable depth is formed of *old-sand*, and on this the surplus quantity for use is gathered together in large mounds.

In working from a pattern in green-sand the object in view is to produce in the finely packed sand a cavity identical in form with that of the pattern; the same being afterwards filled with molten metal and left to cool. To accomplish this the workman is provided with a large assortment of *flasks*, or *molding-boxes* of the most various dimensions; they are designed to hold the sand used in making the molds. Small flasks are simply rectangular frames resembling ordinary boxes, but without either top or bottom; each part being 3 to 6 inches high. They are connected together generally in pairs (often three or more), by *steady-pins*, which allow of their separation when full of sand, and their restoration to exactly the same relative position afterward. Large flasks are provided with cross-bars at suitable distances to prevent the sand, which has been rammed into them, from falling out of its own weight, or rising from the upward pressure of the fluid metal.

In this country, flasks are frequently made of wood; only in the larger foundries is iron used to any extent; but in Europe, and especially in England, wooden boxes are rarely seen. Even where iron is always used, wooden cross-bars are frequently employed with advantage, as they admit of being readily cut away to suit patterns of unusual form. The lower side, or *drag*, has generally only flat bars connecting its lower edges, so that it can be lifted, but not turned over after it is once full. See FLASK.

The following description will serve to illustrate the principles which govern and guide the molder working in green-sand. One flask being laid with its lugs uppermost is filled and rammed up with old-sand, and stricken off level with the joint of the flask: this is called a *false-part*. If now the object to be molded has an elliptical form, as shown in section *b c*, Fig. 3188, the sand in the false-part is cut away roughly, so as to imbed one half of the pattern. Some dry *parting-sand* is next scattered over the surface. This adheres to the damp sand, and prevents any union between such a surface and any other sand subsequently rammed upon it. After the parting-sand is blown off the exposed part of the pattern, the other side or *drag* is put on, its steady-pins entering the holes in the lugs of the false-part easily, but without shake. Newly prepared sand, *facing-sand*, is next sieved over the pattern in sufficient quantity to cover it completely; the box is filled with old-sand from the floor of the shop, and is carefully rammed up and stricken off. After provision is made for the escape of gases from the sand by prodding it all over with a sharp-pointed steel wire, known as a *vent-wire*, the two flasks are held together and turned over on a bed prepared for the drag upon the floor, or on a flat board if the boxes are small, and the false-part, having done its work, is lifted off and emptied. An exact *parting* is now made with the trowel along the median line, if the casting be symmetrical, the damp facing-sand being added to or cut away sharply up to the pattern as occasion may require. The *parting-line* is, as a general rule, that line upon the pattern, as it lies in the sand, above and below which the sides of the pattern run inward from the perpendicular. This is frequently an undulating line, but the parting surface always runs from it in all directions to the horizontal edge of the box. Parting-sand is now strewn over the whole, and the surplus blown off. The upper flask or *cope* being replaced, a short cylindrical *runner-stick* is thrust into the sand of the lower part at a convenient distance from the pattern; facing-sand is sieved on, the box filled up with old-sand, rammed up, and stricken off as before. The vent-wire is then used as with the drag, the runner-stick withdrawn, and the opening left, through which the metal has ultimately to pass to the mold, is given a bell-mouthed shape.

Having arrived at this stage of the work, the molder, either alone if the box be small, or with the help of other workmen or the crane itself if it be large, lifts the cope steadily upward, leaving the pattern in the sand of the drag. The cope is then usually turned over on wooden blocks for repairs and dressing. The pattern is now to be *drawn* from the sand. This is done with the help of spikes or screwed rods, temporarily attached to it; with one or more of these it is lifted, being made to vibrate the while by rapid tapping with a piece of wood or iron, for the purpose of causing it to leave the sand readily. The molder has now to repair with suitable tools any broken parts of the sand forming the mold, then to cut the *runners* or channels from the opening left by the *gate-stick* to the mold, along which the fluid metal finds its way; and lastly to dust finely powdered charcoal from a linen bag over the facing-sand surface, if the mold is for iron, and mill-dust or similar farinaceous substance, if for brass. Charcoal, when this is used, is slicked down with the trowel and slicker as far as possible, so as to bring it into intimate contact with the damp sand. The excess of dust in every case is blown off with the bellows. When the top part is *closed*, it occupies exactly the position it did before; the space then filled by the pattern being now vacant and in connection with the gate, the hot metal can therefore make its way so as to fill such space, the form of which it will be found to have taken when cold.

The foregoing may be regarded as typical of all solid work in green-sand, the imaginary case cited being almost the simplest possible. When hollow work is required, especially if the cavities are long or tortuous, dry-sand or loam *cores* (which see) are employed to form such openings. These are made either by pressing damp sand of suitable composition into a sort of wooden mold, known as a *core-box* (which see), from which it is removed and dried by artificial heat, or by attaining the same end by the use of plastic loam on a perforated barrel or *core-plate*. When such a core is perfectly dry, having received a thin coat of a mixture of clay, water, and charcoal-dust, called *black-wash*, it is placed in position in the mold. This is determined, and the core is held in its place by making it longer than the hole in the casting, and letting the added parts rest in suitable cavities in the sand, made by projections on the pattern known as *prints*. An ordinary water-pipe is a good illustration of this class of work. The pattern for such a casting is solid, and has cylindrical projections of the inside diameter of the pipe at its ends. The long core, through which runs a perforated barrel for the escape of gas, rests upon that part of the mold which is made by the prints, and completely fills those cavities; but it leaves a space all round which exactly represents the pipe, and which is finally filled by melted metal.

b. Dry-sand molding may be regarded as identical in all essential points with that in green-sand, save that the mold when finished is thoroughly and strongly dried by artificial heat. By this treatment the sand especially prepared for the work is baked to a hard compact mass. Dry-sand molding is chiefly used for heavy castings, where great solidity and

strength are required. The drying is done in a heated room called the *stove*.

c. Loam-molding is entirely distinct from the preceding methods of working. *Loam*, as prepared for this purpose, is essentially to be regarded as a mixture of sand and clay, the latter in quantity sufficient to give a plastic character to the mixture when tempered with water to the consistence of mortar or plaster. This material is much used for the construction of large molds and cores, and, as has been previously stated, it obviates the necessity for patterns — generally very costly ones — and core-boxes. Loam cores are *struck* up, usually upon a hollow perforated spindle covered with a layer of hay-rope. The spindle — often consisting of common gas-pipe — is made to run in notched trestles upon which a board (*loam-board*) rests parallel to the axis of the spindle. The loam is heaped upon this board, while the spindle at a proper distance is made to revolve slowly before it by a simple winch-handle. After it is thoroughly dried in the *drying-stove*, it is turned to the exact size, black-washed, and dried again, when it is ready for use.

Loam-molding applied to large castings, such as cylinders, pans, or large water-pipes, is really conducted on principles quite analogous to the above. As a typical instance, the molding of a large sugar or soap boiler's pan is here described. Such a vessel is cast mouth downward. A heavy, flat, cast-iron plate (*loam-plate*) *b*, in the form of a ring, is laid upon the low carriage or truck which runs in and out of the drying-stove. The outside and inside diameters of this flat ring are respectively greater and less than that of the rim of the pan, and it is also provided with four heavy projections by which to move it and the mold upon it, by means of the crane, from the *stove-truck* to the pit in the floor where the casting is made. In the center of this ring rises a perpendicular spindle running in a long bearing provided for it in the carriage, and carrying a movable arm from its upper end. A hollow templet of wood of the exact sweep of the inside of the pan is now clamped to the cross-arm of the spindle, and the latter is lowered so as to bring one end of the templet down to the plate, and there it is fixed. In revolving through a complete circle, the edge of the templet will now describe a figure representing the inside surface of the pan. A rough dome of common brick set in loam is now built upon the ring, keeping it two or three inches clear of the templet, and leaving an opening at top large enough for the spindle to turn in. Loam is then applied to the dome in two or three coats, and it is finally *struck-up*, with the help of the revolving templet, to an exact form. This structure is dried, and then black-washed, and is known in loam-molding as the *nowel*. The templet used hitherto is now replaced by another which gives the form of the outside of the pan. With its help the *thickness* is struck-up upon the nowel, in loam which contains a good deal of clay. It will be seen that this application represents the thickness of metal required for the pan. When dry, it is likewise black-washed, and dried again; the last application in both cases being made to secure a parting. A second cast-iron ring, also provided with heavy ears or lugs, is lowered down till it rests upon that part of the first loam-plate which extends beyond the *thickness*, last applied. A coating of wet loam is then put on with the hand to the surface of the *thickness*, and a second dome of brick is built right against it. When all is dry, the position of the second ring is marked, or secured with pins. The crane is then made fast to it, and the *cope* is lifted off. In all probability the thickness-loam in doing this will break to pieces; if it does not, it is gently knocked away, and both surfaces, that of the *nowel* and *cope*, are repaired and dressed, and finally black-washed. Before this is done the spindle is lifted out, and the opening in the nowel carefully closed; that in the cope usually plays the part of ingate. When both parts of the mold are united, a space now remains corresponding to the *thickness* removed, ready to receive metal. By means of the crane, made fast to the lower ring, the whole is deposited in a pit, and old-sand rammed about it, so as to hold the cope down, and increase its power of resisting the lateral pressure of the metal, which is very great. Adequate provision is also made for the easy escape to the surface of the gases generated by the hot metal, especially those forced inwards through the dried loam and brick-work of the nowel. The formation of the ingate is also carefully attended to.

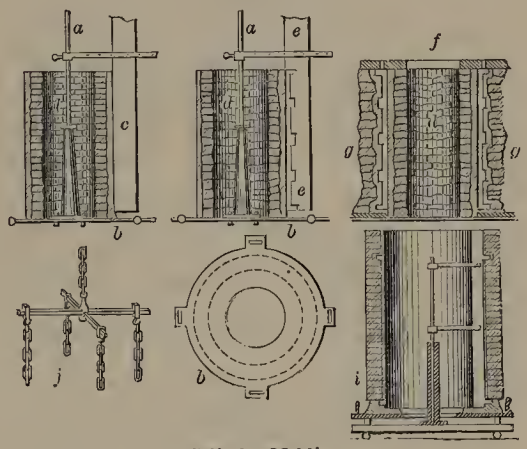
In smaller foundries, and sometimes in those with very perfect appointments, loam-molds are made so large as to render it necessary to dry them *in situ*. In such cases slow-burning fires are made under them in the open shop, and the evaporation of the water is accomplished as best it may.

The *pouring* of brass and iron castings is accomplished from crucibles or ladles respectively. In large iron works several ladles, each containing from two to four hundred weight of metal, are often used simultaneously; for still larger masses, crane ladles holding six or eight tons are employed, and when such are insufficient the mold is filled by leader channels direct from the furnace.

Fig. 3189 shows several stages of the process of cylinder molding by the loam-work process.

A vertical axis *a* is mounted upon a pedestal in the center of the plate *b*, as shown in the figure,

Fig. 3189.



Cylinder-Molding.

or it may be attached to the building or a beam of the roof. A radial arm projects from this axis and carries a *templet c*, which is maintained in rigidly perpendicular position by firm attachment to the radial arm, which rotates with or around the central axis, so that the edge of the templet describes a cylinder in its rotation.

d shows an interior cylinder built up of bricks and plastered over with soft loam, scraped into cylindrical form by the *templet c*, which revolves on its axis. When the surface is made smooth and fair, this part of the mold is dried; it is then brushed over with black-wash and again dried. The charcoal-dust of the black-wash acts as a parting, to prevent the succeeding layers of the loam-mold from adhering to the first.

The cylinder thus made by templet *c c* is the mold for the inner surface of the future cylinder. It is the *core* or *nowel*.

The next figure represents another templet *e e*, attached to the same axis, having an edge conformable in its outline to the *outside* surface of the future steam-cylinder. The distance of the edge of the templet *e e* from the blacked surface of the *nowel* is equal to the thickness required for the steam-cylinder. Loam is placed on the nowel, and smoothed to shape by the revolving templet *e*, which is then dismounted and the spindle removed. The thickness of this loam is represented white in the figure. This loam then receives a coat of black-wash, which prevents it from adhering to the coat to be placed outside of it.

f represents the mold in a farther stage. A wall of bricks *g g* is built around the previous construction, loam being carefully worked against the material which represents the thickness of the future cylinder. The new work or *cope* is now thoroughly dried, and afterward lifted off by means of a crane and a cross-beam with four chains, as shown at *j*. This part of the process usually drags off the thickness of loam which represents the cylinder, and this commonly breaks out during the removal. What remains is carefully picked out of the cope, as it has now served its purpose, and the interval existing between the *nowel* and *cope*, when the parts are restored to their proper relative positions, is to be filled with molten metal to form a cylinder.

When the cylinder requires *ports* at the ends, or the short tube with flanges for attaching the steam-pipes, models of the tube are worked into the cope, and are afterwards withdrawn; the cores are made in core-boxes, and are partly supported by the outward extremity and partly upon *grains*, or two little plates of sheet-iron connected by a central wire, the whole being equal to the thickness of the metal at that point. When steam passages are wanted, either along the side or around the cylinder, they are worked up in clay upon the thickness and duly covered in by the cope; their cores are supported, partly by their loose ends and partly by *grains*, which become entirely surrounded by and fixed in the metal when it is poured.

The mold is now put together in a pit sunk in the floor of the foundry, and the top covered in with a loam-cake, perforated with holes for the entrance of the metal and the escape of the air. The *core* is sustained by iron bars, and the *cope* by iron rings, so as to withstand the pressure of the column of metal.

With some large cylinders, such as those of the Cornish pumping-engines, 80 to 100 inches bore and 12 to 14 in length, also the cylinders of the large blowing-engines of blast-furnaces, the *nowel* and *cope* are made separately, as at *i*. The *cope* is built up and turned inside with a radius-bar; the *core* is erected on a plate on the floor and turned on the outside to a gage; when dried, it is lowered into the cope by a crane.

A modification of the plan for loam-work casting of cylinders and similar large hollow articles, is found in making the cope divisible by a vertical joint, so as to separate laterally into two semi-cylindrical portions which rest upon semi-annular plates, so as to slip back while the thickness representing the metal is removed.

Large water-pipes are cast upon cores, which are made of a layer of loam upon a hay-band wound upon a perforated pipe, the pipe being supported on a bearing, and the loam turned off to a smooth surface, which is dried and black-washed. The *thickness* is laid on and black-washed, and this substitute for a pattern is molded in sand. The core with its envelope is withdrawn, and the *thickness* removed; the core is supported in the mold by the *prints* at the ends and by *grains* with long wires.

Pipes are also made from wooden patterns cut in halves through the axis. The *dray* and *cope* respectively receive the impression of one half, and when the pattern is removed the mold is ready for the core and the making of the ingate.

The molds for crooked pipes and branches are frequently made in halves upon a flat iron plate. An iron bar or templet of the curve required is laid down, and a semicircular piece of wood, called a *strickle*, is used for working and smoothing the half-core; next, a larger *strickle* is used for laying on the thickness; the two halves are then fixed together by wires and molded from in the sand-flask; the thickness is now stripped off the core, which is fixed in the mold by its *prints*, and, if needful, is supported also upon *grains*.

The infinite variety of forms which the molder is daily called upon to reproduce, as well as the constantly varying conditions and materials with which he has to deal, renders his trade an arduous one, requiring much judgment, experience, and forethought. For this reason, also, it is not possible to explain or even enumerate in the space at my disposal the endless modifications of the above typical cases which are constantly occurring. As the best substitute for such exhaustive treatment, however, a list of materials and technicalities used in molding is appended, with explanations designed to elucidate this most important, interesting, and many-sided art.

d. (*Plaster-casting.*) *Waste*-molds are those which admit of but a single cast, from which they are subsequently removed by breaking. *Safe*-molds are those made in a number of pieces, which are so arranged as to be withdrawn separately from the casting and admit of being put together again for a repetition of the process. We are indebted for the invention to the Italians and French of the fifteenth, sixteenth, and seventeenth centuries. With some elaborate subjects the number of pieces required has exceeded 700.

See also STATUARY CASTING.

e. Soft and perishable objects may be so molded as to produce a single casting by one of the several following methods, which are adapted to procuring castings of small animals, insects, flowers, feathers, ferns, sea-weed, wax-models, etc.

1. Support the object in the center of a small box by means of needles, one or two of which should be sufficiently large to form *ingates*. Some fine river-mud is dropped into the box, and shaken around so as to adhere to the object. When partially dry, a coarser grade of silt is thrown in, and successively coarse qualities until the box is filled. The needles and ingate wires are now withdrawn, the mold burnt to reduce the object to ashes, which are shaken and blown out, when the mold is ready for pouring the metal.

2. Another method is to take the object itself or a wax model, such as that of a flower, and suspend it in a box while plaster of Paris is carefully poured around it. The application of heat causes the object to burn or the plaster to absorb the wax, or, if the latter be in excess, it can be poured out. The strings by which the object was suspended are withdrawn, and the mold is ready for casting. The castings may be covered with gold or silver by the electrotype process.

This plan was adopted in casting the feather of the equestrian statue of George III. at Pall Mall, London, and specimens of ears of wheat, flashy flowers,

such as coxcombs, and other beautiful objects, have been exhibited.

Branson, of Sheffield, England, has pursued a somewhat analogous method in obtaining castings from ferns, algæ, etc. A slab of gutta-percha is softened by boiling water, laid on a smooth metallic plate, dusted over with fine bronze-powder, and the frond impressed thereon by a flat upper plate, imbedding the frond in the gum. When cooled, the leaf is withdrawn, and the mold is used to obtain a casting or an electrotype, from which impressions in ink are obtained by the copperplate process.

Auer's plan of *nature-printing* is to impress the frond into soft, polished sheet-lead, by passing between polished rollers. The impression is used for printing, or a copy in a harder material is obtained by the electrotype process.

Wallis's *autographs* were obtained by making drawings in a material which is salient upon the paper, so as to make an impression in the soft plate when the two are passed between the rollers. The plate is used as in Branson's and Auer's processes.

Molders' Terms.

(Referred to at greater length under their alphabetical heads.)

Air or *foul air*. The gases generated in casting, and driven through the sand.

Air-drain. A passage to conduct gases from molds deeply bedded in the floor of the molding-shop.

Air-gate. An opening at which displaced air escapes during pouring, and in which metal afterward rises.

Barm. Yeast used in the preparation of core-sand to render it adhesive.

Bellows. Used to blow loose sand or dirt out of the molds, or parting-sand from the pattern.

Blackening. Charcoal-dust applied to a mold to give smoothness to a casting.

Black-lead. Sometimes used for blacking molds or for mixing with sand.

Black-wash. A solution of clay and powdered charcoal applied to the surface of sand-molds, to give a clean skin to the casting; also used as a parting. See Sand.

Blow. The forcing of displaced air through the molten metal from insufficient vent.

Blown. The condition of a casting containing cavities caused by inclosed air.

Bot. A pear-shaped piece of stiff clay used to stop the flow of metal from the tap-hole of the furnace.

Bot-stick. The rod provided with a long wooden handle at one end, and a small round disk at the other, to receive the clay, used for *botting-off* when the ladle is sufficiently full.

Box. A very common term signifying *flask;* a contraction of *molding-box*. See *Flask*, below.

Brick. Used largely in loam-molding.

Burned in. Union produced by flowing hot metal in quantity over cold.

Burned sand. Sand, the tenacity of whose clayey portion has been destroyed by the heat of the metal. See Sand.

Case. A *cope*.

Cast-gate. The *ingate* at which the metal is poured in.

Chaplet. A wrought-iron stud to hold a core in position in a mold. A *grain*.

Charcoal. Used in dust, as dry *blackening*, or in suspension with clay, as *black-wash* (which see).

Chill. A piece of iron in a mold to suddenly cool the metal flowing against it and render it hard.

Clay. Used according to quality, — fire-clay for walls and boshes of furnaces, commoner for bricks and for loam.

Clay-wash. Clay in solution for smearing the insides of molds and gaggers, to make the sand stick; for cementing the portions of cores; for strengthening loam and adding to charcoal to make *black-wash*.

Cleaner. A tool of thin steel or brass, from 6 to 18 inches in length. One extremity has a bent spatula blade; the other a short blade bent on the flat to a right angle. Used for smoothing the molded surfaces and removing loose sand.

Coal-dust. Powdered coal added in certain quantities to green-sand, according to the quality of the latter.

Coke-dust. The same in effect as coal-dust.

Cope. The flask which is uppermost at the time of casting. The *upper box* or *top-part*. The outside portion of the mold in *loam-work*. Also called the *case*.

Core. A mass of sand, molded and baked, and placed in a mold to form a cavity in a casting.

Core-bar. An iron bar to stiffen a core.

Core-barrel. A perforated iron tube to form a passageway for the gases passing off through the interior of a core.

Core-box. A mold in which a core is formed.

Core-pipe. A core-barrel.

Core-print. A portion of a core which rests in seats in the mold and supports the core in place.

Core-sand. Coarse new sand with powdered loam.

Cotter. A key which locks the steady-pin of a flask.

Cow-hair. Used as a bond to increase the tenacity of loam.

Crane. The hoisting apparatus of a foundry to move heavy flasks, castings, etc. See Crane; Foundry-crane.

Deliver. A pattern is said to *deliver* well when it leaves the sand without breaking down the mold.

Drag. The lower box or bottom part of the flask.

Draw. The taper of a pattern which enables it to leave the sand without impairing the mold. To lift the pattern from the sand.

Drawback. A *false-core*.

Drop. The fall of sand from the top-part into the mold.

Dry-sand. That description of molding done with loam and sand in due proportion, the mold being oven-dried before casting. See Sand.

Drying-stove. A heated room for drying dry-sand molds or cores.

Face-dust. Powdered charcoal for iron castings, mill-dust or pease-meal for brass. It is dusted from a bag over the mold to improve the surface of the casting. Powdered soapstone, rottenstone, graphite, or chalk is sometimes used.

Facing-sand. New-sand used in immediate contact with the pattern, being sifted thereon and then backed up with old-sand and rammed.

False-core. A mass of molded green-sand placed against the side of a pattern which is under-cut. Before drawing the pattern, the false-cores are removed, and are restored before closing the flask. Also called a drawback. See *c*, Fig. 3188.

False-part. A flask temporarily filled with sand in which the pattern is sunk to a parting-line before ramming up the other side of the box which is to form the *drag*. After turning over, the false-part is broken up and the parting properly made.

Feeding-rod. An iron rod for keeping open the *head* or *riser* at which hot metal is added from time to time as the casting contracts in cooling.

Fettle. To clean castings, remove *gits*, *fins*, and *cores*.

Fin. A thin sheet of metal extending along the *parting-line* of a casting where the metal has insinuated itself between the parts of the mold.

Flask. The box or frame which contains the rammed sand forming the mold. The upper part is the *cope*, the lower the *drag*.

Flow gate. An opening from the mold to the surface; in it the metal rises as it is poured into the cast-gate and fills the mold.

Gagger. A double hook hung to the cross-bars of the top-part of a flask, and entering the sand which fills the deep part of a pattern, to enable the sand to be lifted out.

Gate. The opening through a mold into which metal is poured. An *ingate*. Also called *git*.

Gland. A bent rod of iron forming a double hook to lock the parts of a flask together.

Grain. A piece of wrought-iron to hold a core in position. A *chaplet*.

Green-sand. The damp sand of the foundry prepared for molding. See Sand.

Hay-rope. A twisted hay-band wound about a core-barrel in making large cores.

Head. A *flow-gate* or *riser* over the largest part of a heavy casting, in which the hot metal rises, and into which metal is poured from time to time as the metal contracts.

Horse-dung. Introduced into loam, as hair into plaster, to form a bond in dry-sand molds.

Ingate. The opening through a mold at which metal is poured in. A *gate*, *git*, *runner*.

Ladle. An iron vessel, coated with loam, and used to convey molten metal from the furnace and pour it into the mold. One form is a *shanks*.

Lantern. A perforated core-barrel, short, and of relatively large diameter.

Lift. The separation of the cope from the drag.

Loam. A mixture of sand and clay used in molding. See Sand.

Loam-board. A board resting on trestles, and holding the loam used in making cores.

Loam-plate. A flat cast-iron ring on which the *nowel* and *cope* rest in *loam-work*. See *b*, Fig. 3189.

Loosening-bar. A rod extending upward from the pattern through the sand, and which is struck from opposite sides to loosen the pattern in the mold before lifting the top-part.

Metal. The founder's term for cast-iron.

New-sand. Facing-sand next to the pattern.

Odd-side. A permanent *false-part*.

Old-sand. The sand of the foundry floor, killed by use, and not fit for *facing*.

Open-sand molding. A mode in which molds are made in the floor of the foundry without any cope, and usually filled direct from the furnace.

Part. One portion of a *flask*.

Parting. The line of separation between the sand rammed in the respective boxes or parts of the flask.

Parting-line. The line upon a pattern below which it is im-

bedded in the *drag*, and above which it is in the *cope* or top-part.

Parting-sand. Sand free from clay, which is scattered over a green-sand surface where a parting is to be made.

Pattern. The counterpart of a castiug in wood or metal from which the mold iu the sand is made.

Pease-meal. Dusted on as *facing* for molds in brass casting.

Picker. A steel rod with a sharp point, used in picking out small patterns from the sand.

Pickle. Dilute sulphuric acid used in cleaning castings.

Piercer. A vent-wire.

Pot. A crucible, generally of graphite.

Print. A projection on a pattern which leaves a space in the sand for supporting a core in positiou.

Rammer. An implement for compacting the loam around the pattern iu the flask.

Red brick-dust. Sometimes used as a parting-sand.

Riddle. A sieve to mix sand on the floor of the foundry.

Riser. An opening through a mold into which the metal rises as the mold fills, and through which more metal is poured in as the mass contracts.

Run. Said of a mold if the metal iusinuates itself along the parting or otherwise leaks out.

Runner. A channel leadiug from the gate to the space left by the removal of the pattern from the mold.

Runner-stick. A pattern for forming the gate of a mold.

Run-through. When metal is poured in at one gate and runs ont at another. A proccss sometimes adopted in casting a piece solid to auother piece already in the mold.

Sand. Crystalline particles of silica mixed with clay which confers tenacity. Used as a material for ramming around patterns in molding. See SAND.

Sand-burned. Sand partially fused by the heat of the metal and adhering to the casting.

Scoring. The bursting of a casting due to strain in contraction.

Scrap-iron. The spattered masses of iron, wasters, and pieces of iron which have been previously cast.

Shanks. The ladle in which metal is carried froun the furnace to the mold.

Shovel. The implement for heaping sand into the flask.

Shrinkage. The allowance of onc eighth inch to the foot, which patterns are made larger than the casting required, to allow for shrinkago of the metal.

Shuttle. A spade-shaped implement by which the molder stops the flow into the mold in casting direct from the furnaee

Sieve. A wire-cloth sifter for distributing the sand over the pattern.

Skimmer. A bar to keep back slag and dross when pouring from the ladle.

Slag. A basic silicate of iron floating on the metal in the furnace or ladle, and which it is the busiuess of the skimmer to push back in pouring.

Slicker. A small, polished tool for smoothing surfaces of sand in the mold.

Sow. A large channel in the floor of a foundry to hold metal, when heavy castings are to be made without the use of the ladle.

Staple. A piece of iron driven into the sand and projecting therefrom to hold a core.

Steady-pin. Onc of the dowel-pins which form a part of the locking device securing together the parts of a flask.

Stove. The drying-chamber for molds and cores.

Strickle. A straight-edge used to remove superfluous sand from a flask after ramming up.

Strike. The same as strickle.

Strong sand. Tenacious from abundance of clay.

Sullage. The scum, slag, dross floating on metal.

Sullage-piece. An additional length on the upper end of a casting to insure compactness of the lower part. The sullage-piece is afterward removed.

Swab. A soft brush of frayed rope, used in wetting the parting-edge before drawing the pattern.

Swab-pot. An iron vessel to hold water for the swab.

Tap-hole. The opening from which iron flows from the cupola.

Tapping-bar. One for opening the tap-hole by removing the *bot* of clay.

Thickness. The portion of loam, in loam-molding, which represents the object to be cast.

Trestles. Frames on which the perforated core-barrels rest in pipe-molding.

Trowel. A flat-bladed implement used in slicking and parting sand in the mold.

Under-cut. The parts of a pattern in which the sand would be broken by drawing the pattern perpendicularly. The difficulty is avoided by cores, drawbacks, or an additional part to the flask.

Vent. A channel by which air escapes from the mold.

Vent-wire. A sharp-pointed steel wire for piercing sand in the mold to allow escape of air.

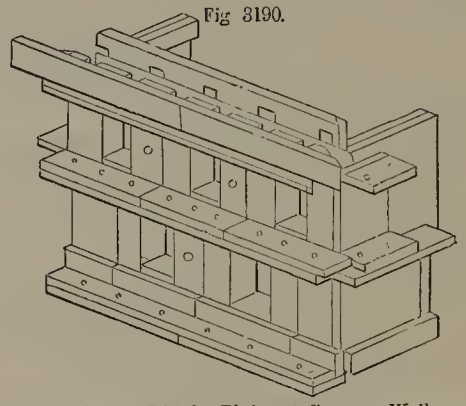
Waster. A spoiled casting; goes to the scrap-heap.

Watering-can. One with a rose to damp the molding-sand.

Weighting. Blocks put on a flask to keep the cope down under the upward pressure of the body of iron poured into the mold.

2. (*Building.*) A frame to give shape to a structure, as in the building of houses in concrete, béton, clay, cement, and what not. In the example, the molds are made in inner and outer sections, which sustain the joists and door and window frames, and between which the concrete walls are formed. The

Fig 3190.

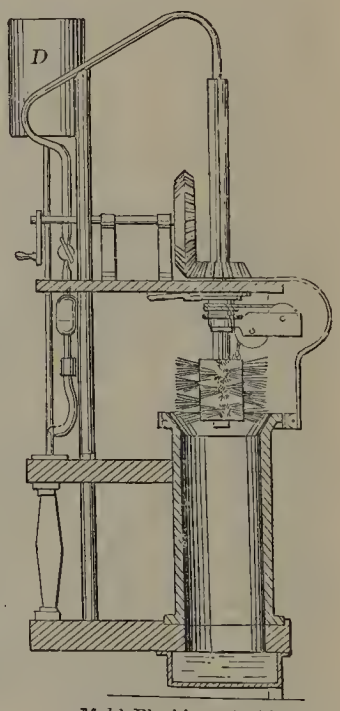


Sectional Mold for Pisé and Concrete Walls.

molds are perforated for admission of air, which supplies carbonic-acid gas. Composition used: sand, 19; hydraulic lime, ½; quicklime, 2.

3. (*Paper-making.*) Hand-made paper is made by a *mold g* and *deckle h*, Fig. 3188. The mold is an open, square frame with a wire-cloth bottom, and a little larger all round than the required sheet of paper. The *deckle* is an open frame, whose inner margin determines the size of the sheet of paper. The *deckle* being laid on the mold, the two are dipped into the pulp, of which a quantity is raised, the superabundance flowing over the edge. The mold being shaken, the water drains away through the wire-cloth, and the fibers become felted together and settle upon the wire. The *dipper* then removes the *deckle* and passes the mold to the *coucher*, who lets it drain a few seconds, and then *couches* the sheet of pulp upon a felt cloth. A stack of alternate sheets and felts to the number of 6 quires of paper, =144 sheets, forms a *post*, which is placed in a screw-press and consolidated.

Fig. 3191.



Mold-Blacking Machine.

4. (*Plastering.*) A thin board cut to a pattern and used in forming cornices, etc. (*k*, Fig. 3188.)

5. (*Shipbuilding.*) *a.* A full-sized pattern of the same figure and dimensions with the molding side of the piece which it represents. The mold may be of skeleton form, and may serve for several frames.

It is usually a thin plank cut to the form of a ship-timber, and serving as a templet for scribing the timbers for the workmen who saw, hew, and adze them into shape.

6. (*Gold-beating.*) The package of gold-beater's skin in which gold-leaf is placed for the third beating. It is first enveloped in vellum, 150 leaves with interposed ribbons of gold, one inch square, forming a *kutch*. The pieces, spreading to the size of the vellum, are cut into four pieces and interleaved with gold-beater's skin; 600 pieces and their skin form a *shoder*, for the second beating.

Being again divided into four pieces, they are again interleaved with gold-beater's skin, making 2,400. These are divided into three packages of 800 each, called *molds*, and receive the third beating.

Mold-black'ing Ma-chine'. One by which a loam-mold is blacked to give it a thin carbonaceous surface; the solution is known as *black-wash*, and is usually put on by a hand-brush; but in pipe and cylinder casting, the insides of the *copes* may be reached by a reciprocating and revolving cylindrical brush supplied through a hollow shaft and tube from an upper reservoir *D*.

Mold-board. 1. (*Plow.*) A curved plate extending back of the share, for overturning the furrow-slice.

The mold-*board*, as its name indicates, was originally of wood, and was first made of iron by James Small, of Berwickshire, Scotland, about 1764. He was the first to make a complete plow of iron and steel, all but the hand-holds for the grasp of the plowman.

Plows are called *right* or *left*, according to the direction in which the furrow-slice is laid. *Double mold-board* plows are those in which the breast is formed by two mold-boards meeting at an acute angle in front of the sheth, and turning the soil equally in each direction.

2. (*Founding.*) A board on which the pattern lies while being rammed. A *follow-board*.

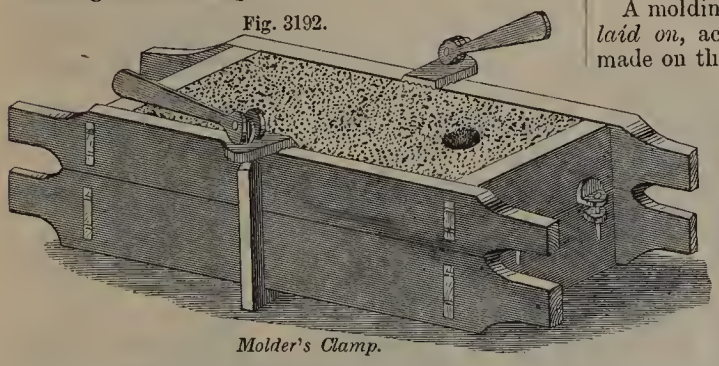
Mold-cis'tern. (*Sugar-making.*) *a.* The vat which receives the drippings from the sugar-loaves.

b. A tank in which the molds are soaked after being used.

Mold'er's Clamp. (*Founding.*) A frame by which the *parts* of a flask are tightly secured together, ready for the pouring of the metal into the mold.

In Fig. 3192, the parts of the flask are clamped

Fig. 3192.



Molder's Clamp.

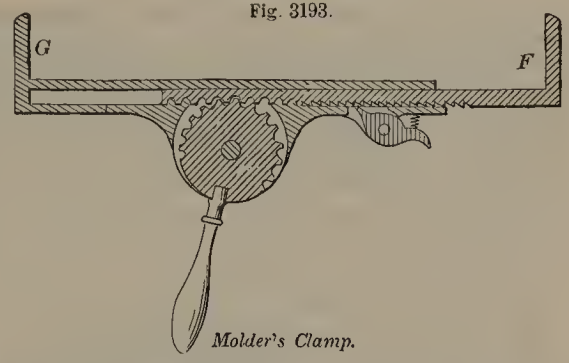
by a hook and a sliding plate, which is depressed by an eccentric pivoted to the shank of the hook.

Fig. 3193 has hooks *F* and *G*, which are drawn against the parts of the flask by pinion and ratchet. The ratchet-arm is worked within the hollow arm by a cog-wheel operated by a lever. Each arm has a hook on its outer end. The spring pawl engages the ratchet-arm to keep it in position.

Mold'er's Flask. (*Founding.*) The frame containing the mold in which metal is poured in casting. See *e*, Fig. 3190. See also MOLD; COPE; DRAG; FLASK, etc. See list under FOUNDING.

Mold'er's Ta'ble. (*Founding.*) A bench at which a workman stands in molding small objects.

Fig. 3193.



Molder's Clamp.

Mold-fac'ing. (*Casting.*) A fine powder sprinkled upon a pattern before covering the latter with loam. It is intended to increase the smoothness of the face of the casting.

Mold'ing. 1. (*Architectural Joinery.*) A mode of ornamentation by grooved or swelling bands or forms, following the line of the object.

a, *bead*, if small; *torus*, if large.

b, *astragal* or *bead*.

c, *cavetto*, *hollow*, *casemate*, or *cove*, according to circumstances or size.

d, *apophygé*, *scape*, *spring*, *hollow congé*, the *echinus* or quarter round. The *echinus* is a *swelling congé*.

e, *fillet* or *list*, if small; *fascia*, if large; *band*, when solitary; *cincture*, when separating the shaft from the capital or base.

f, *Roman ovolo* or *quarter-round*.

g, *Grecian ovolo* or *echinus*.

h, *cyma-recta*, *ogee*, *talon*.

i, *cyma-reversa*.

j, *scotia* or *trochilus*.

k, *quirk*.

l, *cable*.

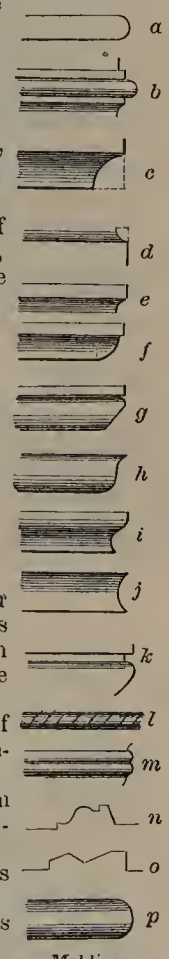
m, *double bead*.

n, *bolection molding*.

o, *canted molding*.

p, *torus*. See JOINERY-FRAMING.

Fig. 3194.



Moldings.

A molding is said to be *stuck on* or *laid on*, according to whether it is made on the edge of the frame or on a detached strip. See STUCK-ON.

A *reeding* is a form of molding resembling a number of bands.

Lamb's tongue is a form sometimes adapted for window-sash.

A *raking* molding has a slanting overhang.

A *crowning* molding is a top member.

A *plain* molding is a mere band.

The student of paleontology finds numerous anticipations of architectural and other ornamentation in the strata of the earth. "In what is known as the modern Ionic the spiral of the volute is not all on one plane; it is a Euomphalus: in the central volutes of the Corinthian the spiral is an open one; it is a Lituite or Gyroceras: in the ancient Ionic it is either wholly flat, as in Planorbus or the upper side of Machrea, or slightly relieved, as in the ammonites. There is no form of the volute known to the architect which may not be found in the rocks, but there are many forms in the rocks unknown to the architect. Nor are the spire-like shells less re-

markable for the rich and varied style of their ornamentation than the whorled ones. They are spires, pinnacles, turrets, broaches; ornate, in some instances, beyond the reach of the architect, and illustrative, in almost all, of his happiest forms and proportions. We detect among the fossils the germs of numerous designs developed in almost every department of art; but merely to enumerate them would require a volume. One form of the old classic lamp was that of the nautilus; another, that of *Gyphæa incurva;* the zigzag moldings of the Norman Gothic may be found in the carinated oysters of the green-sand; the more delicate frettings of similar form which roughened the pillars of a somewhat later age occur on Conularia and the dorsal spines of Gyracanthus. The old corals, too, abound in ornamental patterns, which man, unaware of their existence at the time, devised long after for himself." — HUGH MILLER.

2. (*Pottery.*) Articles of clay are molded upon a WHIRLING-TABLE (which see), or in molds which open and close, like those used in casting metals. In the latter case, the clay is usually rammed into the mold, but for some delicate objects the *slip* or creamy clay is poured into the mold, which is made of plaster, so as to quickly absorb the superfluous water of the filling adjacent. The central fluid portion being poured off, the clay adhering to the mold is allowed to dry, and the process repeated until the required thickness is obtained.

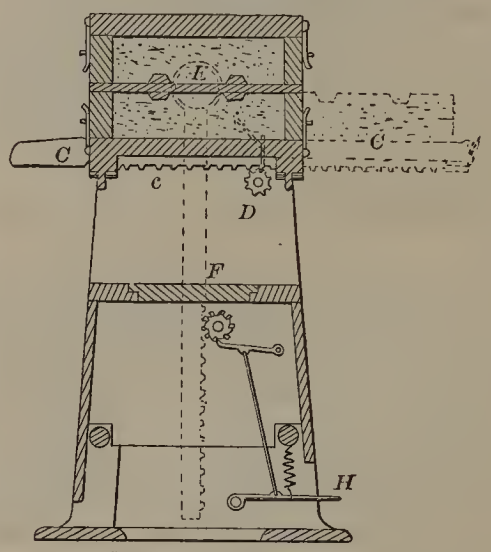
3. (*Shipbuilding.*) Giving the correct outline and depth to ship's timbers, etc. It is one part of the operation of FORMING (which see).

Mold'ing-ap'pa-ra'tus. (*Founding.*) A device or machine for molding. In that represented in Fig. 3195, the operations of molding, facing, drying, coring, casting, and stripping are carried on consecutively, without interfering with each other. The empty flasks from the part *A* of the C-shaped trench *A D D*, which is made somewhat shallower than the rest, are lifted by the crane *F* into *B*, where the molds are cored, tamped, and faced, after which they are lifted by the same crane into the oven *C* and dried. The oven has a door at each end, one communicating with *B* and the other with *D D*, into which, after drying, they are deposited by the crane *G*.

Here the metal is poured by a pot suspended from the crane *G*. When cool, the flasks are lifted by this crane on to the trestles *H H*, where they are delivered, cleaned, and replaced in *A* to again undergo the same series of operations.

In Horrobin's machine (Fig. 3196) the flask is placed on a sliding carriage moved by a rack and

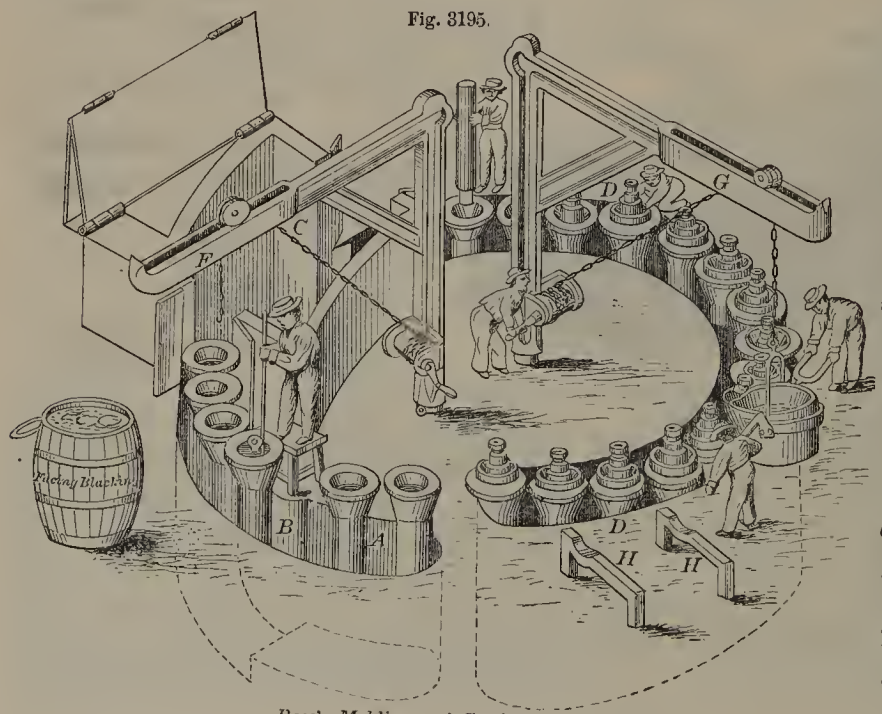
Fig. 3196.



Founder's Molding-Machine.

pinion *C D*. The follow-board *E* is journaled on top of the rack *f*, so that it and the flask may be lifted and turned over, in order that a mold just made may be examined while another is being made on the other side. The rack *F* is raised or lowered by depressing the treadle *H*, which releases a pawl from the rack-pinion, and turning a crank on the pinion-shaft.

Fig. 3195.



Ross's Molding and Casting Apparatus.

Mold'ing-board. (*Founding.*) The board on which the pattern lies when ramming the loam. A *follow-board.*

Mold'ing-box. (*Founding.*) See FLASK; MOLDING.

A *flask* in which the sand is rammed.

Mold'ing-crane. One for handling molds and flasks in a foundry. See FOUNDRY-CRANE.

Mold'ing-edge. (*Shipbuilding.*) That edge of a ship's frame which comes in contact with the skin and is represented in the draft. The other edge is the *beveling-edge.*

Mold'ing-file. A file with a concavity adapted to dress and finish molded surfaces. It is made by a swage and afterward cut.

Mold'ing-frame. (*Founding.*) The tem-

plet by which an object is shaped in loam-molding.

Mold'ing-hole. (*Founding.*) The cavity in the floor of a foundry in which large castings are made.

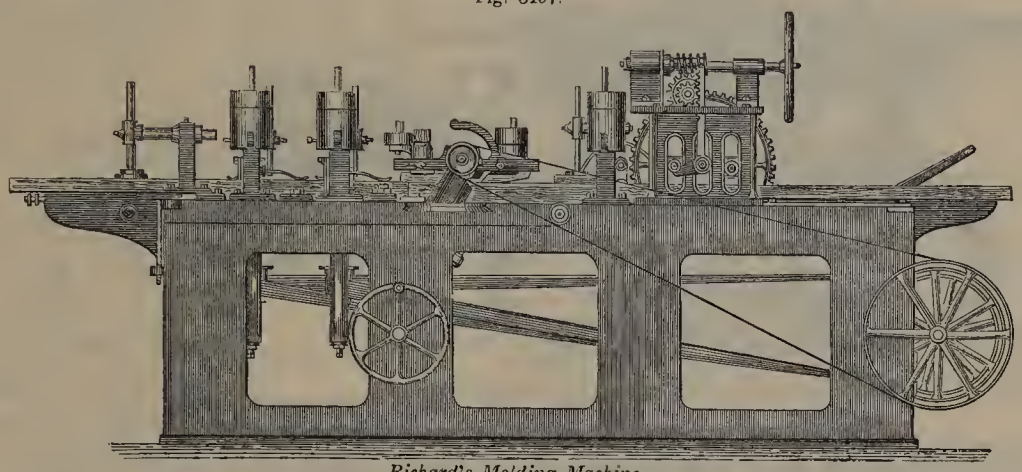
Mold'ing-loam. (*Founding.*) The mixture of sand and clay used in loam-molding.

Mold'ing-ma-chine'. 1. (*Wood-working.*) The rotary molding-machine for wood is enumerated among the inventions of General Samuel Bentham, previous to 1800. It had rotary cutters. One form of his machine was for making wave-moldings, and had an undulating bed.

There are several forms of the machine, one of which is a modified planing-machine; the other is an outgrowth of the same, but has a peculiar construction.

Fig. 3197 is a side elevation of a molding-machine

Fig. 3197.



Richard's Molding-Machine.

to plane four sides of the lumber. A roughing cylinder is placed in front of the main profile cylinder, to smooth the bottom of the lumber before it reaches the bed under the main cutters. The profile cutting on the under side is performed by the cylinder at the rear end of the machine. The cutter-heads are five in number, on steel spindles. The feeding mechanism is on top of the machine, raised above the cutting mechanism. The lumber is fed in at the end of the machine, gripped by the feeders, supported by the bed, and passed in contact with the revolving cutters in turn. See PLANING-MACHINE, WOOD.

Fig. 3198 is a perspective view of a machine for working heavy moldings, either three or four sides at one operation. The revolving head on the main spindle is slotted to receive a number of cutters, so as to make a molding of the profile required. The main feeding-roll is in the bed, and does not show in the figure; the adjustable swinging feeding-roll above is made in sections, and is so hung and geared as to be parallel with the lower feeding-roll. The lower horizontal cutter-head is in the bed, and does not appear; the upper head and the side cutters, on vertical spindles, are shown. The latter are driven by crossed belts.

Fig. 3199.

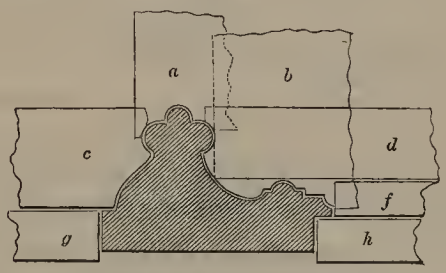
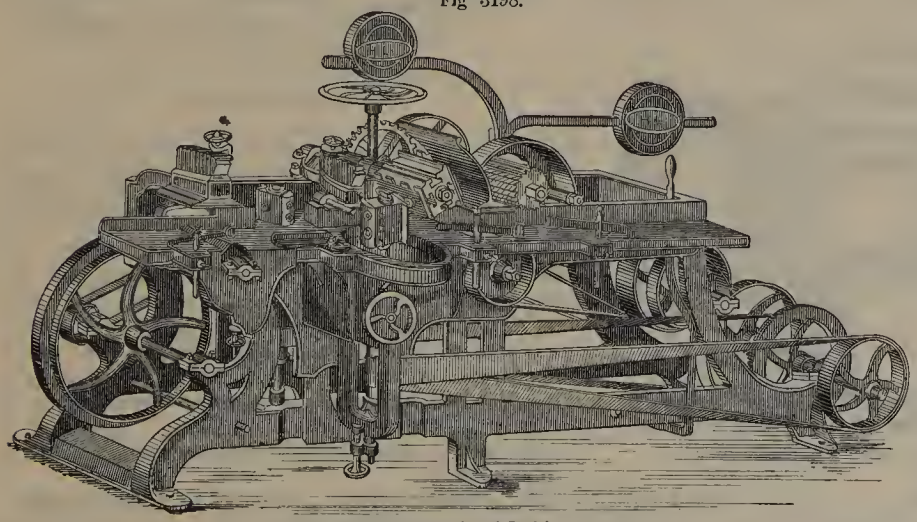


Diagram of Cutters for Molding.

Fig 3198.



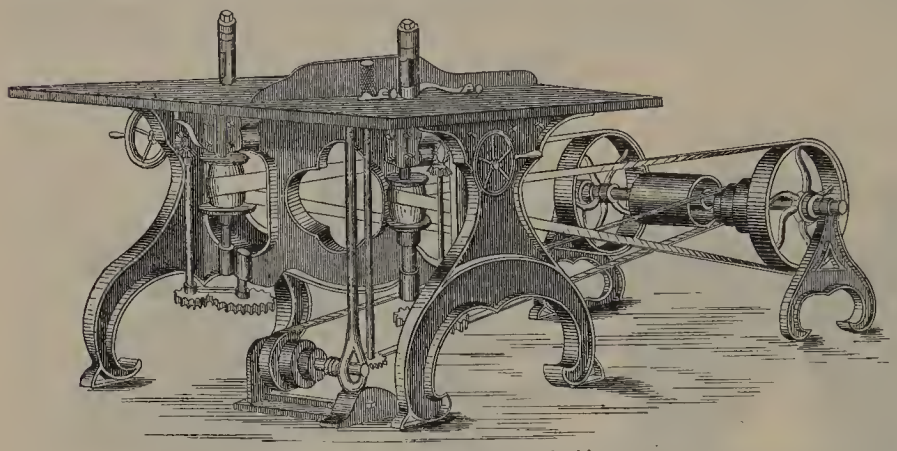
Fay's Molding Machine.

Fig. 3199 is a diagram showing the arrangement of cutters and their relative position to make undercut picture-frame molding, with rabbet for the glass and picture. It will be seen that of the side cutter-heads one has three knives and the other two; the upper head has two knives.

Another type of *planing and molding machine* is shown at Fig. 3200. A broad table rests upon an iron frame at the usual hight of a carpenter's bench, and rising from the surface near one

end are the heads of two vertical spindles or shafts, which project but a few inches. In the heads are planing-irons, shaped to suit the work required, and the heads form a guide or gage to the pattern to which the material to be dressed is temporarily attached by a few metallic points. The pattern being

Fig. 3200.



Variety Planing and Molding Machine.

carried past and against the heads while rotating, the material upon it is planed and molded to the shape of the pattern and knives used. By the graduation of the knives, the machine may be adapted to work of any size, making the heads even from one half of an inch to four inches in diameter; so that the machine may be used in doing delicate irregular woodwork.

It is now used in planing the wood handles to hair-brushes, and also in dressing plow-beams and the knees of ships.

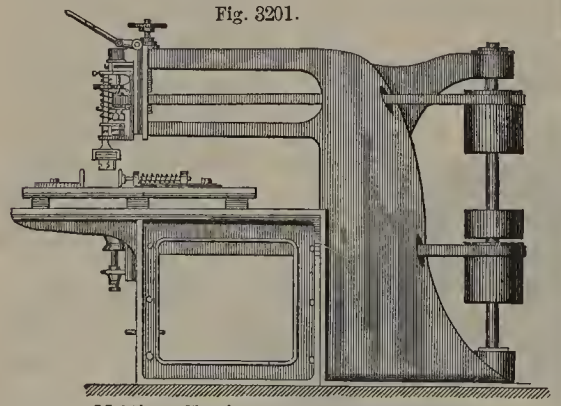
The engraving represents upon the table-top of the machine a guide, connected with which is a feed-roll, which receives power to move it from the pulleys beneath the table, and when attached completes the machine for doing straight as well as irregular work.

By the hand-wheel arrangement, represented at each side of the machine, the spindles are raised or lowered, as occasion requires, adapting the cutters to the thickness of the material operated upon.

This machine is analogous to the *milling-machine* for metal.

Fig. 3201 is a side elevation of a molding, shaping, and recessing machine, applicable to a number of

Fig. 3201.

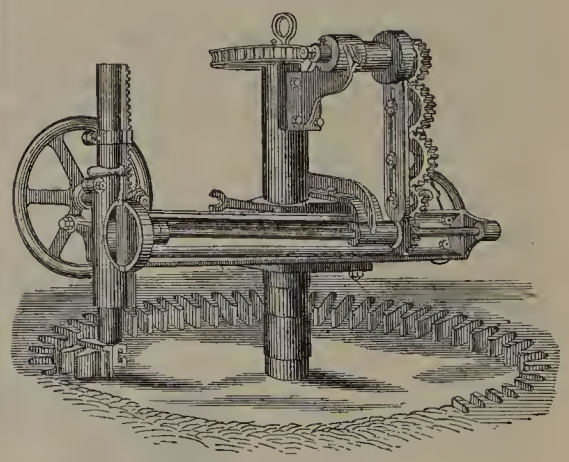


Molding, Shaping, and Recessing Machine.

purposes, among which may be mentioned cutting curvilinear moldings, sticking circular and straight sash-bars, molding, rebating, and grooving square or circular sash-frames, forming moldings round raised door-panels; molding, chamfering, or edging flat ornamental balustrades, to patterns; forming the housings in string-boards for stairs; sinking recesses of any design, etc. The machine is furnished with top and bottom vertical cutter spindles, driven from an intermediate shaft at the back. The upper spindle is lowered into the work by depressing a handle; directly the handle is released, the cutter rises from the work through the agency of a strong spring affixed to the slide. For recessing, suitable stops are provided, to regulate the depth. When striking moldings, a fixed table is employed, but for recessing, curvilinear work, etc., a table on friction rollers is substituted. The lower cutter-spindle revolves in a reverse direction to the upper, and is useful for certain kinds of work. See CARVING-MACHINE.

2. (*Founding.*) Fig. 3202 is a view of a molding-machine for gear-wheels, in which a pattern is used corresponding to a small portion of the gear to be molded. This pattern includes two teeth and the

Fig. 3202.



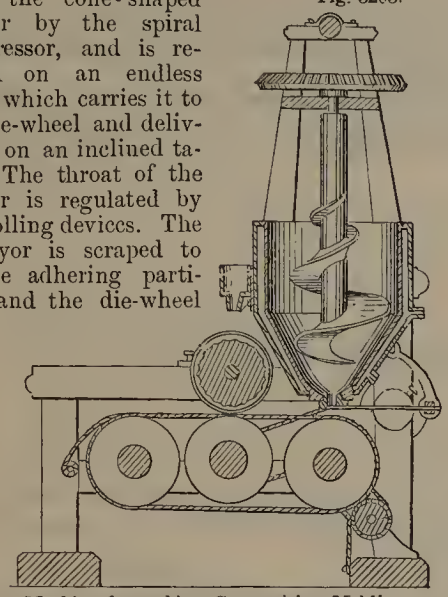
Gear-Molding Machine.

interdental space, when spur-gears are to be molded. It is attached to the lower end of a vertical guide-bar, which slides in ways formed at the end of a horizontal support, which has a radial position relatively to a central vertical spindle or arbor. By this means the pattern is carried around, and, being made to descend, makes the proper impression for that portion of the gear-wheel or pulley which corresponds to it. It is used to mold gear-wheels from nine inches up to six feet in diameter, — either spur, bevel, miter, mortise, or worm wheels, plain or shrouded, — and it is also equally applicable to molding fly-wheels or pulleys, either whole or fitted in segments.

3. (*Plastic-work.*) A machine for the manufacture of composition-molding. The material is driven

from the cone-shaped hopper by the spiral compressor, and is received on an endless apron which carries it to the die-wheel and delivers it on an inclined table. The throat of the hopper is regulated by controlling devices. The conveyor is scraped to remove adhering particles, and the die-wheel

Fig. 3203.

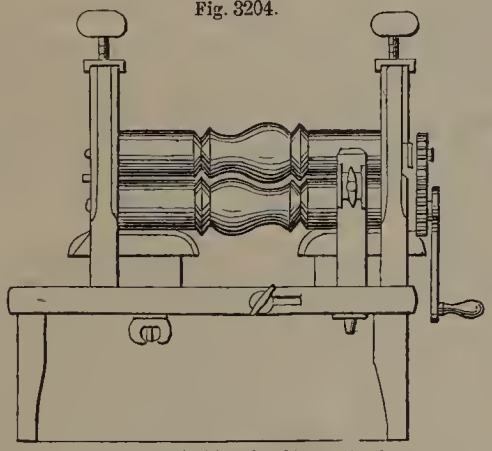


Machine for making Composition-Moldings

oiled to prevent adherence of the composition. The principle is the same as some of the brick, tile, and pipe machines (which see).

4. (*Sheet-metal Working.*) A kind of rolling-machine for molding sheet-metal to shape for cornices, balusters, and other purposes. It consists of a pair of rollers of counterpart form, between which the sheet of metal is passed to give it the required outline.

Fig. 3204.

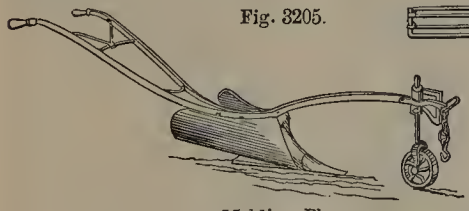


Molding-Machine for Sheet-Metal.

Mold'ing-mill. A planing-mill for shaping timber. See MOLDING-MACHINE, 1.

Mold'ing-planes. Joiners' planes for making moldings, and having various patterns, or concave and convex soles to form parts of moldings. Such as *hollows* and *rounds*. *Match-planes.*

Fig. 3205.



Molding-Plow.

Mold'ing-plow. A plow with two moldboards to throw the soil right and left. A *ridging-plow*. Used for molding or forming ridges, striking water-courses, or hilling-up potatoes; so constructed as to thoroughly turn the soil, burying the surface and bringing up the bottom. That shown is made entirely of iron, having a trussed beam and front wheel, and may be used for splitting ridges; the breast is laterally expansible, and the penetration of the share is regulated by the draft-chain at the clevis.

Mold'ing-saw. One or a number of circular saws for blocking out strips for ornamental moldings.

The strips are fed repeatedly to the saw at different angles, and the general outline of the desired molding approximated. The work is generally completed by revolving planes.

Mole. 1. (*Husbandry.*) A cylindrical plug of iron, three or four inches in diameter, and with a sharp point, drawn or driven through the subsoil to make a drain.

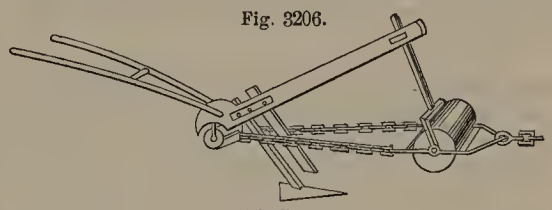
2. (*Maritime Engineering.*) *a.* A jetty or structure erected before a port so as to partially inclose a harbor or anchorage, and protect it from the violence of the waves in the offing.

b. A pier of masonry; one is described by Herodotus as extending around the harbor of Samos.

3. A mausoleum of peculiar form, as the mole of Hadrian, now known as the Castle of St. Angelo, Rome.

Mole-plow. The mole-plow has a pointed iron shoe, which is attached to the end of a standard and drawn along underground, making a track like that

Fig. 3206.



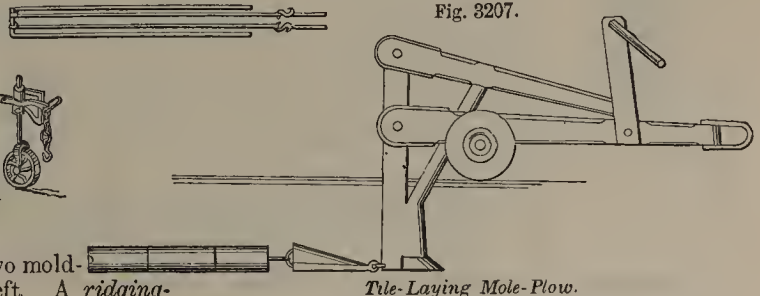
Mole Plow.

of a mole, establishing a duct to lead water from the subsoil, pressing the earth away, but not purposely disturbing the surface.

It is said to have been invented by Adam Scott (British), and will be easily understood by the illustration. The work is all beneath the soil, in positions where a surface drain is inadmissible, the thin colter to which the *mole* is attached only making a mark which is soon obliterated. It was used in draining the marshes of Essex, England, during the latter part of the last century.

In a modification, the mole is attached by a short chain to the bottom of the sharp standard, to permit the *mole* to avoid obstacles, and by lessening its rigidity increase the ease of traction. Fig. 3207 is a tile-laying mole-plow. The cutter-bar is pivoted to the carriage, and adjustable to vary the presentation of its foot by means of an upper beam to which it is attached and braced. A mole trails behind the

Fig. 3207.



Tile-Laying Mole-Plow.

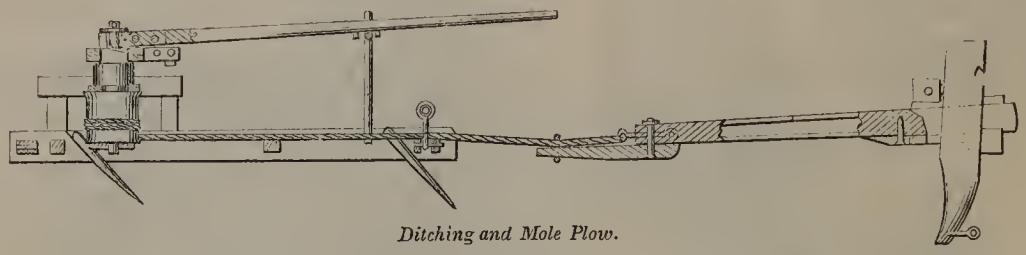
cutter-foot, and by means of a cord, hooks, and cross-bar the tiles are drawn in behind the mole.

A mole-plow for laying tiles was made about 1850, and exhibited by Foules, the inventor, at the meeting of the Royal Agricultural Society of England of that year.

Attached to the mole was a rope, upon which the sections of tile were strung, and the mole as it progressed drew in 300 feet of tiling after it. A hole was dug at each commencement of operations. See DRAIN-TILE.

It is sometimes drawn by four or six horses, and, perhaps, more often by a rope from a capstan, as in Fig. 3208, in which the capstan is shown anchored

Fig. 3208.



Ditching and Mole Plow.

in position, and the standard of the mole-plow has a clevis for the attachment of the mole.

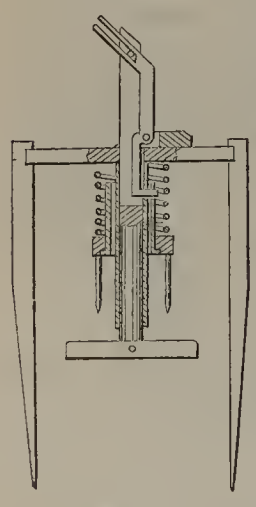
The *mole-plow* is described in White's English patent for a draining implement, 1797. It is thus described in a report, November, 1797 : —

"The principle of this invention consists in the patentee's mode of forming a sort of subterraneous channels, cavities, soughs, or drains, from every part of the ground to be drained, which channels run into a principal drain or ditch, cut by hand in the usual way. These subterraneous channels he forms by a particular species of share, foot, or wedge, affixed to a sort of plow, which is drawn by horses in the usual way.

"In the beam of the plow is fixed a vertical plate of iron, about 24 inches long, and called, from its sharp steel edge, the *cutter*. To the bottom of this cutter is fixed a solid *wedge*, *foot*, or *share* of cast-steel or wrought-iron, 12 inches in length, 2¼ to 3 inches thick, and 2½ to 3 inches deep at the base, and terminating (forward) in a sharp point. This *wedge*, before the plow is put in motion by the horses, is introduced into the ground as deep as may appear to be necessary ; and, by its passage under the surface, it forms the subterraneous channels which carry off the moisture to the main or principal drain.

"To lessen the resistance against the sharp edges of the cutter and wedge, in their passage through stiff soils, a circular or rolling cutter may be fixed immediately before the perpendicular cutter, or a shorter vertical cutter, at the pleasure of the maker."

Fig. 3209.



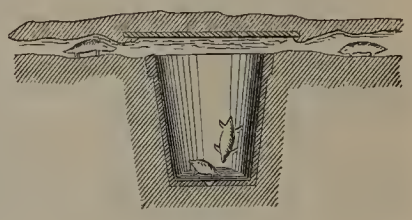
Mole-Trap.

Mole'skin. (*Fabric.*) A strong cotton twilled goods for men's wear. A kind of fustian, cropped or shorn before dyeing. *Beaverteen.*

Mole'trap. One placed in a mole-burrow to catch the mole. There are several kinds. In one, the mole, in attempting to effect a passage underneath the cross-bar on the lower end of the trigger-staff, actuates the trigger, and releases the tube carrying the prongs, and is consequently impaled by the latter.

Fig. 3210 shows a flower-pot placed with its mouth on the level of the track of the mole. Over the top of this receptacle a piece of board is placed, leaving a space of about three inches between it and the edge of the pot, so that dirt from above will not fall into the latter. The openings of the run lead into this space. The earth is replaced and the surface of the ground restored. The mole, in following his usual road, blindly comes to the orifice leading to the pot, into which he tumbles.

Fig. 3210.



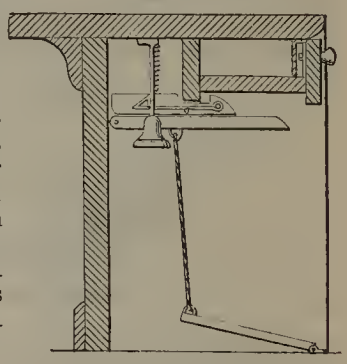
Mole-Trap.

Mol'le-bart. (*Agriculture.*) A Flemish implement consisting of a large shovel drawn by a horse and guided by a man. A *mold-board* or *earth-scraper*.

Mol-yb-de'num. A metal : Equivalent, 46 ; symbol, *Mo.* ; specific gravity, 8.62 ; it gives a greenish flame under the blow-pipe ; a salt of this metal is used as a test for soda. It is not much used in the arts.

Its sulphide is a soft black mineral frequently mistaken for graphite. In 1778 the Swedish chemist Scheele decided that it was really a different mineral ; and in 1782, Hjelm prepared from it a new metal, to which was given the name molybdenum, the sulphide having received the name of molybdenite. It may be distinguished from graphite as follows : On unglazed porcelain the former gives a greenish streak and graphite a black ; molybdenite is decomposed by nitric acid, leaving a white or grayish residue ; graphite is unacted upon by acids ; on charcoal before the blow-pipe the former gives a strong sulphurous odor and coats the coal with crystals of molybdic acid ; graphite is infusible, but at a high temperature with access of oxygen burns without flame or smoke. Molybdenum is not usually met with in large quantities, but has been found in crystals and plates at various places in the United States. See GRAPHITE.

Fig. 3211.



Till-Drawer Alarm.

Mon'ey-draw'er A-larm'. A device which strikes a bell when the till-drawer is opened. A cleat on the lower rear portion of the drawer engages a latch, and rings the bell, when the drawer is opened or closed. A treadle withdraws the latch to avoid the noise. A spring wire locks the drawer, and is unlocked by the motion of the knob.

Mon'ger. A small fishing-vessel.

Mon'i-tor. The popular name for a class of American iron-clad vessels, having one or more turrets, and a peculiar formation of hull. So called from the first vessel of this construction, built for the United States by Captain John Ericsson, and launched early in 1862.

The original "Monitor" was based on a system proposed by Captain Ericsson to the Emperor Louis Napoleon in 1854. In 1855 Captain Coles of the Royal Navy proposed a system of revolving turrets to the British government, which was adopted after the "Monitor" had demonstrated the value of the invention. Captain Coles was lost in the iron-clad frigate "Captain," a vessel of his own construction, in a gale off Cape Finisterre in 1870. See Plate IV. for a view of the *Captain*.

Prior to the inventions of Ericsson and Coles was a proposition of Mr. T. R. Timby, of Massachusetts, who sent drawings of his proposed turret ships and batteries to the United States Patent Office in 1843. His right to the invention was afterward recognized by the United States, and a royalty paid to him. The evidence tends to show that neither one of these engineers was aware of the invention of the others prior to the completion of his own.

The contract for building the "Monitor" was awarded September 16, 1861. Captain Ericsson says: "In order not to lose time, the Secretary ordered me to 'go ahead at once.' Consequently, while the clerks of the department were engaged in drawing up the contract, the iron for the keel-plate of the 'Monitor' was drawn through the rolling-mill."

The contract for Captain Ericsson's battery specified that she was to be 172 feet long, 41 feet beam, 11½ feet hold, 1,255 tons displacement. She was to be completed in 100 days.

The construction of the "Monitor" was different from that of any vessel preceding her. Besides the revolving turret and low deck, the upper part of the hull had a square projection over the lower part, some 6 feet wide on the sides and 25 feet astern. This "overhang" served to make her much steadier in a sea, but was supposed to be the cause of her final loss. The deck was 18 inches above the water-line, and composed of one-inch plates of rolled iron. The turret was 20 feet in diameter and 9 feet high, built of thicknesses of one-inch rolled plates, and covered with a grating of railroad bars supposed to render it bomb-proof, with a roofing above to keep out water. The turret was pierced for two guns, and carried two 11-inch Dahlgrens. The guns and turret rested on a post or pivot amidships, which supported the whole weight, and was turned by the engines. The boilers and engines were aft, leaving the forward part of the hold for quarters for the crew and storage of ammunition. The pilot-house was forward, and had lookout-holes for the steersman or commander. (See also Plate IV., opposite page 150.) She was described by the Southern journals as "a black Yankee cheese-box on a raft."

The engagement of the "Monitor" and "Merrimac" in Hampton Roads, March 9, 1862, was an event of history, and need only be mentioned here as having decided the fate of wooden vessels for naval contests.

At that time the "Monitor" undoubtedly proved herself the most formidable craft afloat.

Subsequent engagements with shore batteries pointed out a few defects in construction, the worst one being the location of the pilot-house forward of the turret, interfering with the pointing of the guns in that direction. In subsequent monitors the pilot-house was mounted on the turret. Some other minor changes were also made. The original "Monitor" maintained her supremacy until her loss in a heavy storm off Hatteras, December 31, 1862. She is supposed to have been strained in falling with the seas, and parted between the lower hull and the overhang, carrying down four officers and twelve men with her. A part of the crew were saved by the steamer "Rhode Island."

After the success of the "Monitor," a large number of iron-clad vessels of similar or analogous construction were built for the United States government. The "Weehawken," one of the earliest, was plated with 6-inch armor on deck, 11 inches turret, and carried one 11 and one 15 inch gun.

In an engagement between the "Weehawken" and the Confederate iron-clad steamer "Atlanta," June 13, 1863, the latter was disabled at the fourth shot from her antagonist, and surrendered, having lost 16 men wounded and 40 knocked down by a 15-inch shot which broke through her 4-inch iron and 18-inch timber armor, although striking at an angle of 50°.

In the various engagements with the fortifications at Charleston, the "Weehawken" was struck 187 times by shot and shell without serious damage to vessel or crew.

Admiral Dahlgren reported that the nine iron-clads of the monitor pattern, during the operations against Morris Island, fired 8,000 projectiles, weighing 365 tons, and were struck 882 times, mostly by 100-pound shot, without receiving any very severe injuries. In giving his opinion as to the comparative value of iron-clad vessels, Admiral Dahlgren says: —

"The armament of the monitors could be perfected to give all desirable rapidity of fire, but by no contrivance could a broadside vessel be enabled to use much heavier guns than those now mounted. . . . . There remains to the monitors the advantages of lighter draft, choice of guns from the heaviest to the lightest, defensibility, and direction of fire around the whole circle; consequently the ability to carry a heavy battery into the least depth of water, with equal power of offense and defense in any direction, and that with half the number of guns carried in broadside by another vessel."

Admiral Porter, after a lengthened experience with all sorts of iron and wooden vessels in action under almost all possible circumstances, gave his opinion that the monitors built on the Western rivers were the most powerful vessels of war ever launched. He says: "The first monitor was a perfect success, and capable of defeating anything that then floated." The one first completed at Cincinnati, in 1864, he thought, "could commence at Cairo and, going down the river, destroy everything we have on these waters, unless they ran away"; and this without disparagement to the powerful fleet of vessels then on the Mississippi, several of which had received over a hundred shots each, while under the Admiral's command, without apparent damage. Of the monitors at Charleston, he says: "They have done what no other vessels ever built could possibly have accomplished."

Some 50 monitors were built for the United States government, between the years 1861 and 1867. Of

these, some have one, some two, and some three turrets, each turret to contain two guns. The general principles were substantially the same in all, and the Ericsson plan of iron-clad vessels may be said to cover nearly everything in the way of armored ships now in the United States navy. The guns mounted on the monitors are generally 15-inch Dahlgrens, carrying a projectile of 450 pounds. A few 20-inch guns, to throw a shot of 1,100 pounds, have been made, but these are now at the Navy Yard in Brooklyn, and none have yet been tried on shipboard.

The British Admiralty adopted a modified form of monitor or turret vessel, constructed according to the plan of Captain Coles, who built some very formidable vessels; but, in his efforts to increase the offensive efficiency, overloaded the vessels with upper works. This was most apparent in the "Captain," which is shown in Plate IV. (opposite page 150), in a group of iron-clads, American and British. This vessel capsized off Cape *Finisterre*, July, 1870, and was indeed the "end of earth" to the crew of 500 officers and men, and also to Captain Coles, who went down with her. The "Captain" was a double-turreted vessel, each turret carrying two 25-ton guns; armor of from 6 to 10 inches thickness, and had other upper works, fore and aft, also pierced for guns.

The same plate also shows the very formidable vessel, the single-turreted "Glatton," which was selected to be a target for 600-pound elongated projectiles of the "Palliser" order. She bore it very satisfactorily. In the same group is also the "Thunderer," a double-turreted vessel of a favorite class. It may be described as a monitor based upon the American models, but with variations introduced with a view of removing the more objectionable features of the monitor system. Thus, instead of having as low a freeboard as possible, a hight of four feet six inches has been allotted to the hull above the water-line; the turrets, instead of being exposed, are protected by a powerful breastwork; and, instead of being constructed upon as small a scale as possible, she has been built on a scale sufficient to enable her to carry an armament of four 35-ton guns, with the capacity of storing during a voyage a supply of 1,750 tons of coal. With such capabilities as these, she has a burden of 4,500 tons, a length of 285 feet, and an extreme breadth of 62½ feet; and, large as these proportions are, one of the few defects the British Committee of Ships' Designs find in her is that she is not large enough, and that in future such vessels should be built upon a larger scale than either the "Thunderer" or the "Devastation." See IRON-CLAD.

Mon'i-tor-car. (*Railway.*) One having a central longitudinal raised portion in the roof, on the sides of which portion are openings for ventilation and panes for light.

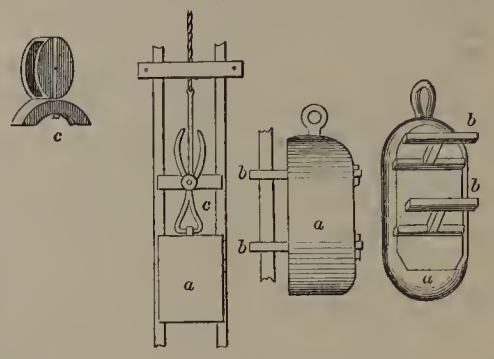
Monk. (*Printing.*) A blacker portion in a printed sheet; a dark patch. A blackened, wasted impression.

Mon'key. 1. The weight (*a*, Fig. 3212) of a pile or post driver, which is raised by a grapple and chain, and, being detached, is allowed to fall in its guides on to the head of the pile. The weight is attached to the chain by a dog *c*, which is caused to relax its grip by a trigger, or by coming in contact with a stop placed at the required hight.

At the back of the *monkey*, or *ram*, are two frames *b b* in the form of an H, which serve to guide the weight when rising or falling. See PILE-DRIVER.

2. (*Forging.*) A vertical hammer, consisting of a long bar of iron, running loosely through an eye, several feet above the anvil, and terminating at foot in a mass of iron, called the *ram*. The shaft is raised by a chain and drum driven by the engine, and has an automatic releasing apparatus, which is regulated to drop the monkey at the required

Fig. 3212.



Monkey.

hight, say with a range of from 2 to 5 feet. The monkey has a horizontal range of, say 20 inches, and is made to drop upon the spot required by means of guy-rods in the hands of two workmen.

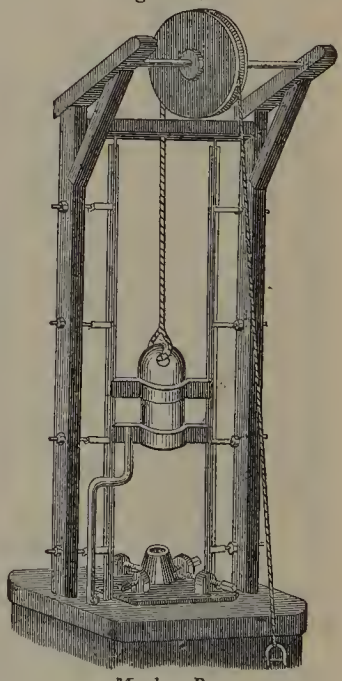
Mon'key-block. (*Nautical.*) A single block (*c*, Fig. 3212) strapped to a bridge-piece which is bolted to the deck or other object.

Mon'key-boat. A small boat used in the docks.

Mon'key-en'gine. A form of *pile-driver* having a *monkey* or *ram* weighing about 400 pounds, moving in a wooden frame. The monkey is held by a staple in a pair of tongs, and is drawn up 10 or 15 feet, or higher if necessary, by means of a winch. At the top of the lift the handles of the tongs come in contact with two inclined planes, which cause the tongs to open and drop the monkey. The tongs, being then lowered, become self-engaged with the staple, and so the work proceeds. See PILE-DRIVER.

Mon'key-ham'mer. A drop-press in which the hammer is a falling weight; called by the same name as the hammer of a pile-driving machine. In it various articles of jewelry, etc., are stamped out, the strip of gold being laid upon the lower die and impressed between it and the upper die, which descends in guides when the workman slacks the rope by raising the stirrup.

Fig. 3213.



Monkey-Press.

Mon'key-press. A hammer in which the driver consists of a *monkey* which is alternately raised and dropped, sliding in guides. One form of *power-hammer*.

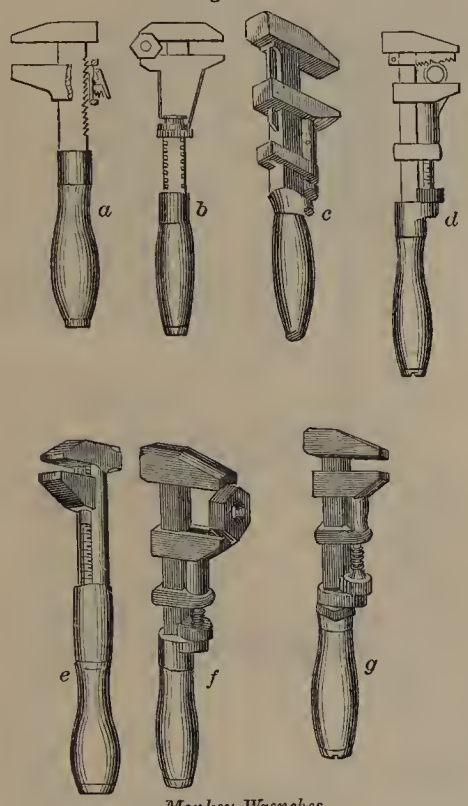
Mon'key-pump. The sailor's name for the sucking straw introduced at a gimlet-hole in a wine-cask. This is as old as Xenophon, who describes this mode of pilfering from the wine-jars of Armenia.

Mon'key-rail. (*Nautical.*) A supplementary rail, above and lighter than the quarter-rail.

Mon'key-tail. A small iron crow-bar used by naval gunners.

Mon'key-wrench. A spanner with a movable jaw. The cut shows several kinds.

Fig. 3214.



Monkey-Wrenches.

a has a spring-dog on the back, catching into a ratchet.

b has one jaw for hexagonal and another for square nuts.

c shows a strong form with a spline.

d has a serrated jaw to grasp a pipe.

e has a screw concealed in the stock.

f has a capacity for gripping a hexagonal nut by the points of its jaws.

g is an ordinary machinist's wrench of good quality.

Monk-seam. (*Nautical.*) A double seam of a sail made by overlapping selvages and sewing both edges.

Mon'o-chord. (*Music.*) 1. An ancient instrument with one string which was played as a guitar. It grew into a *manichord*, in which numerous strings were played by quills. See MANICHORD; PIANOFORTE.

2. An instrument for experimenting upon the mathematical relations of musical sounds. It consists of a single string, stretched between two bridges, one or both of which are movable, and which stand upon a graduated rule, for the purpose of readily changing and measuring the length of the part of the string involved in the vibration. (WEBSTER.) Sometimes called the *harmonical canon*.

Mon'o-chro-mat'ic Lamp. A lamp fed with a mixture of a solution of common salt and alcohol. It gives a yellow light and a ghastly appearance to the human face, objects appearing yellow or black. Useful in photographic studios.

Mo-noc'u-lar Mi'cro-scope. A microscope adapted for one eye, in contradistinction to a *binocular* instrument.

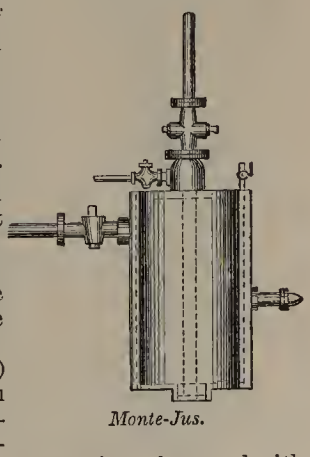
Mo-noc'u-lus. (*Surgical.*) A bandage to retain a topical application over the eye.

Mon'o-gram. A cipher composed of two or more letters interwoven as an abbreviation of a name. Monograms were common as distinctive marks on ancient coins, and were also used as devices on seals.

Mon'o-lith. A single column or block. The term is applied to such erections as the obelisks of Egypt, some of which are now in Rome and Paris. (See OBELISK.) The term *monolithic* is also applied to structures in which the blocks are immense, in some cases reaching from the foundation to the entablature, as in the United States Treasury, Washington. This building is said to have larger stones than any used in the pyramids of Egypt, and to be of a more massive construction in respect of the size of its stones than any other building in the world, except the church of St. Isaac at Petersburg, Russia.

The largest existing monolithic temple in Egypt is that of Tel-el-mai, on the Delta. It is 21 feet 9 inches high, 13 feet broad, and 11 feet 7 inches deep. This size is much exceeded by the dimensions given by Herodotus of the temples of Amasis and Latona, which were also, we are informed, on the Delta. The former one, he states, required three years to transport, with the aid of 2,000 laborers, from Elephantine to Saïs, a distance ordinarily of twenty days' Nilotic navigation. The temple of Latona was still larger. "The most wonderful thing," says Herodotus, "that was actually to be seen about this temple was a chapel in the inclosure made of a single stone, the length and hight of which was the same, each wall being forty cubits square [sixty feet], and the whole a single block. Another block of stone formed the roof, and projected at the eaves to the extent of four cubits." According to these measurements, supposing the walls to have been only six feet thick, and the material granite, as in all other monoliths, this monument would weigh 7,000 tons, being 76,032 cubic feet, without the cornice, which was placed on the roof. This capstone would weigh 2,400 tons, if six feet be taken for its thickness. If any doubt exists respecting the ability of the ancients to transport and uplift such enormous masses of stone as these, it is set at rest by M. Jomárd, the celebrated Egyptologist, who gives a sketch, in his work on Egypt, published by the French government, of a huge block of granite situated almost a quarter of a mile from the modern town of Syene, where it was abandoned for some unknown reason while on its way from the quarry. It bears numerous traces of instruments in the work on its surface, as well as evidences of its having been intended for a colossal statue. M. Jomárd's dimensions are, — the largest, $22\frac{2}{10}$ meters, and for the body and back $6\frac{1}{2}$ meters, or about 72, 21, and 21 English feet, which, at 13 cubic feet per ton, yields nearly 2,500 tons. See also MASONRY, where the stones of Baalbek are noticed.

Fig. 3215.



Monte-Jus.

Monte-jus. (*Sugar.*) A force-pump by which the juice from the cane-mill is raised to the clarifiers on the story above. It consists of a vessel with

a sunken well in the center of the bottom, and having three pipes: one by which the juice is received; another whose open lower end is near the bottom of the vessel, and by which the juice is discharged; a third by which steam is admitted. Each has a valve. The cistern being charged and the induction valve closed, steam is admitted, which presses on the surface of the liquid and drives it out by way of the ascending pipe. The valve in the steam and eduction pipes being closed, the steam condenses, the induction pipe is opened, and the cylinder refills. Repeat the operation.

Mon'ton. A heap of ore; a batch under process of amalgamation, varying in quantity in different mining districts.

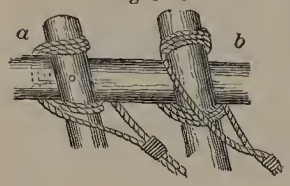
Moon-knife. A knife employed by skinners. The blade has a crescent shape, and is sharpened on its convex edge.

Moon-rak'er; Moon-sail. (*Nautical.*) A sail sometimes carried above the sky-scraper.

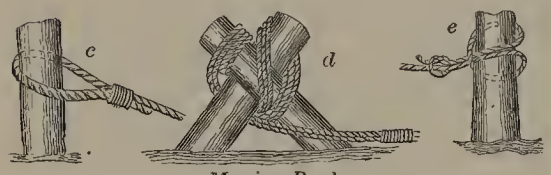
Moon'stone. A variety of adularia of a white color and opalescent reflections.

Moor'ing. (*Nautical.*) *a.* A sailor's bend for a cable or hawser to a bollard, post, or ring, for a ship or a flying bridge.

Fig 3216.



a, square mooring.
b, crossed fastening, the rope being crossed at the back.
c, simple fastening.
d, loop-fastening.



Mooring-Bends.

c, Lark's-head fastening to running knot. See BEND; CHAIN-FASTENING; WATERMAN'S-BEND.

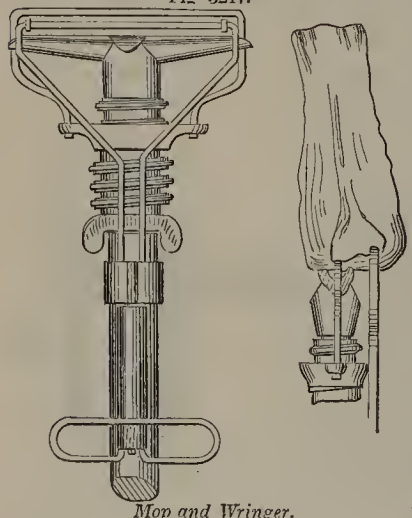
b. A submarine holdfast in the ground. See ANCHOR; SCREW-PILE; MUSHROOM-ANCHOR.

Moor'ing-swiv'el. (*Nautical.*) A chain over the bow, having the strength of the two cables to which it is swiveled. It enables a ship to ride from two anchors and swing without fouling.

Moot. (*Shipbuilding.*) *a.* A gage-ring for determining the size of tree-nails.

b. A piece of hard wood, hooped with iron at both ends, used in block-making.

Fig 3217.



Mop and Wringer.

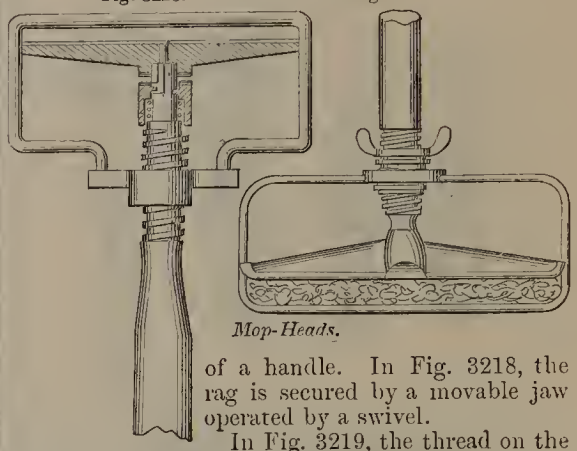
Mop. A scrubbing-rag or bundle of junk secured by a handle.

In the example of a domestic mop, the rag is held between jaws, one of which is movable, by means of a screw. A wringing device is attached, consisting of a bent wire, which is passed through the mop and secured to the handle; to use the wringer, detach the wire and turn it in the hand, twisting the mop-rag.

Mop-board. (*Carpentry.*) A wall-board next to the floor of a room. A *skirting-board.*

Mop-head. A clamp for a mop-rag on the end of a handle. In Fig. 3218, the rag is secured by a movable jaw operated by a swivel.

Fig. 3218. Fig. 3219.

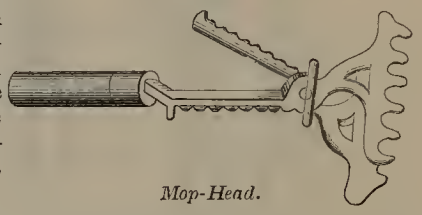


Mop-Heads.

In Fig. 3219, the thread on the handle has its socket in the thumb-nut, and the reverse thread on the latter has its socket in the collar of the yoke.

In Fig. 3220, the mop-cloth is clamped between toothed jaws, whose shanks are hinged and fastened by a ring.

Fig 3220.



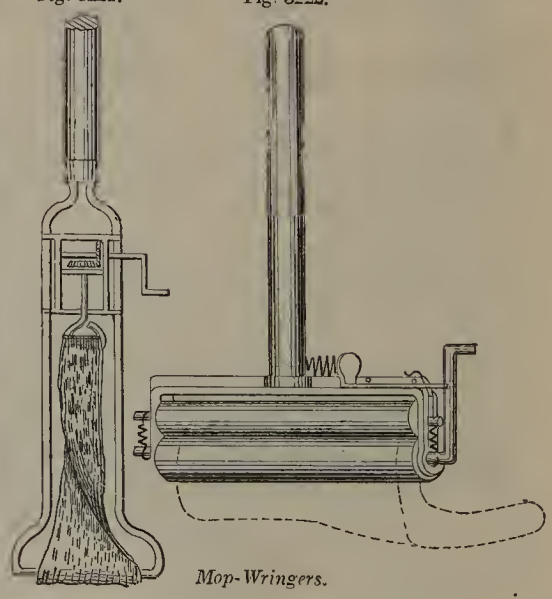
Mop-Head.

Mop-nail. A flat-headed nail, used in securing a bunch of junk or rope-ends to a handle in making a mop such as sailors use.

Mop-stick. (*Music.*) A vertical damper-rod at the end of the key in the old piano-forte movement, single action. When the key was depressed, the mop-stick was raised and the damper therewith. As the key rose, the damper fell back on to the string.

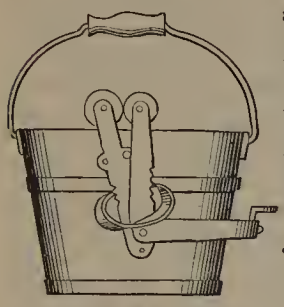
Mop-wring'er. (*Domestic.*) A device to wring

Fig. 3221. Fig. 3222.



Mop-Wringers.

Fig. 3223.



Mop-Wringer.

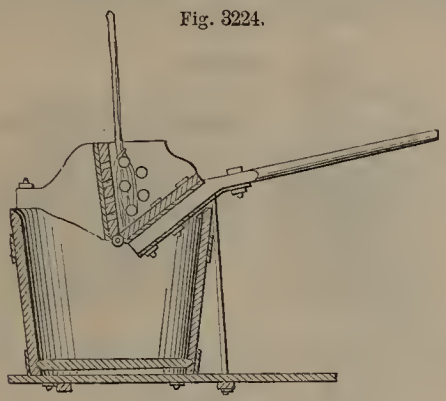
or squeeze the water from a mop. In Fig. 3221, the sliding frame with the twisting device is drawn up near the handle when the mop is to be wrung.

The example (Fig. 3222) has a pair of wringing rollers.

In Fig. 3223, the roller jaws are attached to a pail, are approached by a clasping spring, and opened by pressure on a treadle.

In Fig. 3224, the perforated boards are hinged together, the lower one is fixed, and the upper one has a lever and side-strips.

Fig. 3224.



Mop-Wringer.

The mop is pressed between them and drains into a bucket.

Mo-quette'. A fine tapestry or Brussels carpet. A species of Wilton carpet.

Mor'dant. A substance applied to a fabric to give a fixity to the dye.

1. (*Dyeing.*) Mordants were known to the natives of India, and perhaps of Egypt, in the time of Pliny, who was suffocated by sulphurous fumes or carbonic acid in the year 79. "Their fabrics are first imbued, not with dyes, but with dye-absorbing drugs, by which, though they seem to be unaltered, yet when immersed in a caldron of the boiling dye-liquor they are found to be painted. Yet, as there is only one color in the caldron, it is marvelous to see many colors imparted to the robe, in consequence of the influence of the pigment. Nor can the colors be washed out."

He farther remarks to the effect that a number of colors in the caldron would only give a neutral, blended, or confused effect; but, owing to the previous treatment, which made no visible stain, capacity was conferred upon the cloth for so appropriating the color, that different parts obtained different tinctures, according to a specific faculty for adoption and conversion due to the previous preparation in each case.

2. (*Gilding.*) A sticky substance to cause gold-leaf to adhere to an object.

Mo-reen'. (*Fabric.*) A watered woolen or wool-and-cotton goods, for hangings, curtains, upholstery, and heavy skirts.

Morn'ing-star. A weapon used in ancient times and as late as by the train-bands of London, in the time of Henry VIII. It consists of a ball with spikes, united by a chain to a staff.

Mo-roc'co. A fancy leather tanned with sumach and dyed. Used for bookbinding, ladies' shoes, upholstering furniture, cushions, etc.

The Saracens, on their expulsion from Spain, carried with them into Africa their art of preparing leather, and it is now named from the place to which the manufacture was then removed, — Morocco.

True morocco leather is prepared from goat-skins, but sheep-skins are extensively used in the preparation of an inferior quality. The coast of Barbary yet yields a large supply of goat-skins for the morocco-leather manufacturers of France and England.

For some centuries the principal supply was from the Levant, which still yields a large quantity of goat-skins and morocco leather.

The operations in the manufacture of morocco are substantially similar to those through which hides for upper leather are passed.

The *unhairing* process is followed by treatment in a tumbling cylinder in which the hides are agitated and beaten to remove some of the lime, and this is followed by *bating*, which neutralizes the remainder of the lime and renders the leather pliable.

The coloring, if red, precedes the tanning; dyeing with other colors follows tanning.

In dyeing red, two skins are sewed together by the edges, the flesh sides facing each other. The bag thus made is inflated with air, and the distended bag is dipped into the mordant and then into the dye.

The mordants and dyes are according to the color.

For red morocco, —

Mordant: alum or chloride of tin.

Dye: cochineal with or without saffron.

For morocco of other colors the skins are tanned previous to dyeing. They are placed in a revolving cylinder, with a warm solution of sumach. The process takes 24 hours, and the hide is then rinsed, dried, and dyed.

For dyeing, two skins are united by their edges, flesh sides in, so as to prevent the waste of dye by coloring both sides.

The dyes used are campeachy wood, indigo, or Prussian blue.

Quercitron for yellow.

Sesquiacetate of iron for black.

Blue and yellow baths in alternation for green.

Blue and cochineal for violets and purples.

Quercitron and cochineal for orange.

The dyed skins are pressed in a hydraulic press to remove superfluous dye-stuff, *beamed*, *dried*, *slicked*, *pommeled*, and *grained*.

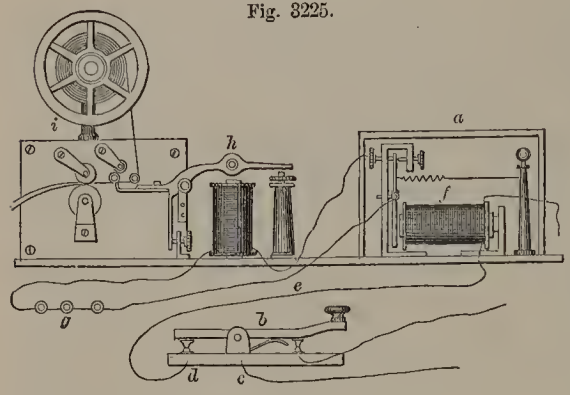
The latter confers the peculiar appearance on the leather, and is done by hand or by machinery. The leather is indented by rollers which have raised parallel, straight, or diagonal threads, producing a wrinkled appearance.

See Muspratt's Chemistry, II. 530.

Morse Al'pha-bet. The telegraphic alphabet contrived by Professor Morse, and which has practically nearly superseded all others on land routes in the United States and on the continent of Europe, is composed of a series of dots and dashes. Though adapted for being instrumentally recorded on paper, it is usually read by sound, the receiving telegraphist writing down the words as they are transmitted.

Fig. 3225 is the Morse telegraph apparatus, with relay *a*; the invention of Professor Henry of the Smithsonian Institution. The key *b* being up, a current arriving by the line-wire *c* passes from *c* to *d*, thence through *e* to the coil of the relay *f*, and through this to the earth. The electro-magnet of the relay attracts an armature, whose contact completes the circuit through the local battery *g*, in which the coil that operates the armature *h*, constituting the indicator, is included. *i* shows that part of the appara-

Fig. 3225.



A ·—	M — —	Y —·— —
Ä ·—·—	N —·	Z — — ··
B —···	O — — —	Ch — — — —
C —·—·	Ö — — —·	Understood ···— —
D —··	P ·— — ··	1 ·— — — —
E ·	Q — — ·— —	2 ·· — — —
É ··—··	R ·—·	3 ···— —
F ··—·	S ···	4 ····—
G — —·	T —	5 ·····
H ····	U ··—	6 —····
I ··	Ü ··— —	7 — — ····
J ·— — —	V ···—	8 — — — ··
K —·—	W ·— —	9 — — — — ·
L ·—··	X —··—	0 — — — — —

Morse Apparatus and Alphabet.

tus by which the message may be impressed on a slip of paper, if required.

Mor'tar. 1. (*Grinding.*) A vessel, generally in the form of a bell or conical frustum, in which substances are pounded by a pestle. When large, they are made of cast-iron ; a smaller size is made of bronze, and those for more delicate pharmaceutical operations are of marble, pottery, porphyry, or agate. They are used in connection with a pestle, which in the larger mortars is of iron and in the smaller is of porcelain or agate. The Wedgewood ware has long been a favorite for this purpose.

The difficulty is to find a material for mortar and pestle which will not scratch. Scratching is abrading, and adds a dust of the material of the mortar to the ingredients under treatment. This may be unimportant in many cases, but sometimes may fatally impair the chemical purity of the substance.

In the accompanying illustration, *c*, Fig. 3226, is from the tomb of Rameses III. at Thebes, and represents a man working in an Egyptian kitchen. The man is pounding something to be used in cooking.

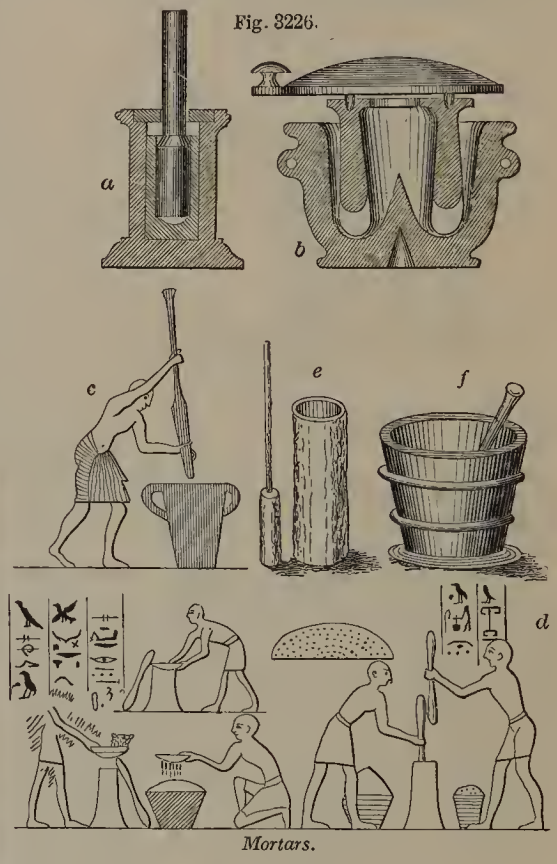
In ancient Egypt, as in modern, pounding substances in stone mortars in the public streets was and is an ordinary sight. The articles are brought to them by the inhabitants, and may consist of grain, salt, etc., which are pounded, sifted, and delivered. The figures *d* fairly represent the operation. One man appears to have a pan of the crude material in his hand and to be about to tip it into his mortar. In another place two men are using the pestles, giving alternate blows. Another man is sifting the stuff, whatever it is. Overhead is a piece of perforated metal which gives an indication of the nature of the process. The pestles are of metal, the mortars of granite, scooped out to about half its depth. The public practice of this industry is stated by Wilkinson to continue to this day.

The upward growth of the soil of Egypt by the deposits of the Nile has no doubt hidden thousands of these heavy tools, which were too heavy to move and had nothing in them to tempt the predatory bands by which that unfortunate country has been overrun at and since the time of Cambyses.

The mortar and pestle probably constitute the original appliance for grinding grain.

In many parts of the United States, and doubtless in foreign countries, remain many large, hollowed stones on which the grain of a community or tribe was pounded. Among the North American Indians the corn was reduced by this means to hominy or coarse meal, so as to be fit for making into cakes or mush. The present generation yet points to these stones in the neighborhood of the former sites of Indian villages. They are usually large surface stones of the bowlder type of rock, and probably had an incipient hollow, of which advantage was taken in forming the mortar.

Fig. 3226.



Mortars.

Besides this, or in place of it, some tribes had hollowed sections of tree-trunks, as among the Japanese of the present time. Throughout that country rice is *hummeled* in a wooden mortar.

Wedgewood ware appears to fulfill the requisitions for a good mortar better than any other substance, porphyry excepted. The great difficulty in working the latter has been a bar to their introduction. The French have made them as large as 29 inches in diameter.

A mortar should be able to resist scratching by steel, quartz, or flint. Should not be stained if sulphate of copper or muriate of iron be left in it for twenty-four hours. Should not be abraded by the rubbing down of an ounce of sharp sand to a fine powder. The pestle should possess the same character.

Mortars of iron, brass, marble, dolomite, and glass are acted on by particular solvents, especially acids.

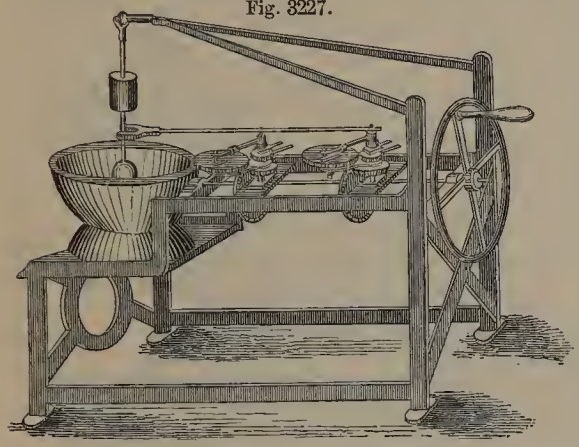
They are also too soft for many purposes. The color-mortar *b*, used in the porcelain manufactory of Sêvres, has a projecting conical piece in the center, which forms with the sides of the mortar a circular trough in which the pestle rotates. The pestle is a cylinder of porcelain, rounded at the bottom, and weighted with a disk of lead at the top, to which the handle is attached.

The colors are finished on a porphyry slab.

The mortar *a* for crushing diamonds for lapidaries' use is of hardened steel with a cylindrical cavity, and has a hardened steel pestle fitting neatly therein. The pestle is pounded with the hammer, being partially rotated between each blow. The diamond, though hard, is brittle, and is reduced to powder of the required fineness by this means.

A machine in which the pestle receives a motion similar to that imparted by hand is shown at Fig.

Fig. 3227.



Goodall's Grinding and Levigating Apparatus.

3227. As it traverses a different surface each rotation, no scrapers are required to keep the powder constantly under action.

A weighted lever secures the pestle at the top, and gearing from which it derives motion is driven by bevel gear from the main driving-shaft. The mortar is in front, to be out of the way of dust from the moving parts of the machinery. The pestle is attached to the driving-shaft by a screw, and may be removed when required.

B, Plate XXXV., ORE-MILLS, shows a form of mortar with a pestle traveling in a circular groove around a central post to whose horizontal arm the upper end of the inclined pestle axis is journaled. This block is of very hard stone, preferably porphyry, and has a grinding as well as a mashing action.

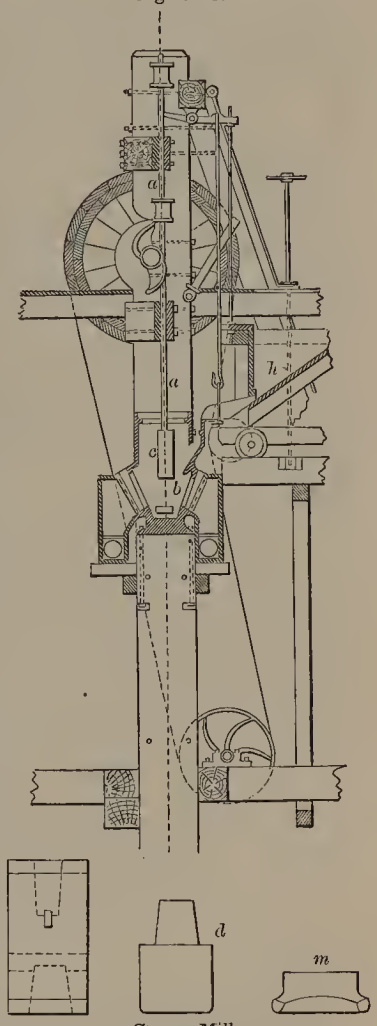
In the same plate is also a form of pulverizer known as the Chilian mill, having a stone traveling around its circular track and rotating on the horizontal axis rigged out from the vertical axis which is stepped into the middle of the table. See also CHILIAN MILL.

Fig. 3228 is a view of a stamp-mill for silver ores, in which *a* is the stamp-stem, *b* the mortar, *h* the hopper-car with the argentiferous rock, the feed being automatic by a tappet on the stamp-stem when the ore has become reduced to *slimes* and has floated off. The cut is a general view of the stamp, frame, and driving machinery.

Below are shown on a larger scale the *socket* or *stamp-head*; *d* is the *shoe*; *m* is the *die* which is placed in the bottom of the mortar. The shoe and die are removable.

2. (*Cement.*) A calcareous cement. It differs in its characteristics according to the nature, proportions, or treatment of its constituents.

Fig. 3228.



Stamp-Mill.

The Romans are remarkable for their great use of calcareous cements, both the ordinary lime mortar and that mixed with volcanic matter from Puteoli, now Pozzuoli, from whence the name *pozzuolana*, commonly known as Roman cement. This material consists of porous, half-concreted volcanic matter, which is mixed with lime or common mortar to give it the property of hardening under water. It is mentioned by Vitruvius and Pliny.

The use of lime in England, as we gather from the accounts of Julius Cæsar, was not known previous to the Roman conquest. The oldest limestone quarry in England was opened by the Romans at Tadcaster in Yorkshire, called Calcariæ in the Roman itinerarics. The quarry is still used.

Lime most commonly occurs in the state of carbonate, such as marble, calcareous spar, oolite, limestone, or chalk.

Some limestones include in their composition so large a proportion of iron and clay as to enable them to form cements which have the property of hardening under water, and are called hydraulic limestones. The proportions of clay vary in different quarries, and often in the same from 8 to 25 per cent.

The pozzuolana consists of oxide of iron and burnt clay, and performs the same office as the clay in the above-cited limestones, acting with great energy in "setting" under water.

Limestone reduced to the finest powder is inefficient in the composition of mortar, but requires that the carbonic acid shall be eliminated by heat. This begins at the outside and proceeds to the center of the masses of stone. As the lime grows cold it commences to absorb carbonic acid, and, if time permit, will return to the state of carbonate.

When cold water is poured on a piece of well-burned lime, a large quantity is rapidly absorbed, the lime heats, exhales steam, and falls into dry powder. The weight of the lime is increased about 24 per cent, and it becomes a hydrate, or slaked lime. This hydrate is the ingredient in mortar. Carbonate of lime, as has been said, is not efficient in this connection.

Hydrate of lime may be made into a paste, but will powder or dissolve when dry. The admixture

of sand gives it the character of cement. The proportion of sand to lime, cited by Pliny, is round grained sand, 3; lime, 1; or sharp pit-sand, 4; lime, 1. He also recommends the use of pounded tiles. This is bringing in the clay element, cited above.

The common London mortar is sharp river sand, $2\frac{1}{2}$; white chalk-lime, 1.

The cohesion of the two is due probably to something more than mere mechanical contact, as is proved by the fact that while a paste of chalk and sand is nearly as coherent as a mass of hydrate of lime and sand, the former will not harden into a cement and the latter will.

The moles and other marine structures of the Romans were cemented with a composition of lime, 1; pozzuolana, 2. Smeaton used, in building the Eddystone Lighthouse, hydrate hydraulic lime, 1; pozzuolana, 1. It was rendered plastic by continued beating.

Aiken states the general theory as follows: In the white limes or nearly pure carbonates of lime the only effect of burning them is to drive off the carbonic acid. By slaking, the lime becomes a hydrate, and in this state is capable of acting chemically, though feebly, on the surface of pure siliceous sand. This combination causes the first setting of the mortar, which is also strengthened by the mere mechanical action of the sand. The greater part, however, of the lime has not combined with the sand, but remains in the state of a hydrate. In proportion as this latter absorbs carbonic acid from the air, it gives out its water and passes to the state of carbonate; such mortar, therefore, acquires its final induration and dryness when the whole of the hydrate has been decomposed and the water has been replaced by carbonic acid. In losing 22 per cent of water it combines with 46 per cent of carbonic acid, and, therefore, the mortar becomes the more solid and strong.

In the blue limes, part of the calcareous matter combines during the burning with the silica, alumina, and oxide of iron constituting the intimately mixed ferruginous clay, forming a compound that gives to the cement made of it the property of setting speedily in the air or under water. The rest of the lime passes, by slaking, into the state of hydrate; and, if only siliceous sand is present, acts on it in the same manner that white lime does; but if ferruginous sand or burnt ferruginous clay be present, the hydrate acts more rapidly and powerfully on the clay, sooner gives out its water and consolidates. Whether this latter compound is afterward decomposable by exposure to the carbonic acid of the air, it is difficult to determine.

In those limes which contain naturally so much ferruginous clay as, after burning, to form cements without the addition of sand or other ingredient, the greater part of the lime is probably combined with the clay in the act of burning, a very small quantity of hydrate formed, and very little carbonic acid reabsorbed.

Dr. Artus's method of making mortar is to take well-slaked lime, 1 part, and mix carefully with it finely sifted sand, 3 parts; just before using add one quarter as much fine unslaked lime as there has been sand used, and mix thoroughly. While it is being mixed the mass heats and the silicates form through which it quickly stiffens and becomes very hard in a short time. This mortar resists all action of water, and can be used wherever durability is an object.

The Egyptian mortar, in some instances, was destitute of siliceous sand, its place being occupied by coarse powdered gypsum or native sulphate of lime.

Stone mortar. 8 parts cement, 3 parts lime, and 31 parts of sand.

Brick mortar. 8 parts cement, 3 parts lime, and 27 parts of sand.

Brown mortar. Lime, 1 part; sand, 2 parts; and a small quantity of hair.

Khorassar, or *Turkish mortar*, used for the construction of buildings requiring great solidity. $\frac{1}{3}$ powdered brick and tiles, $\frac{2}{3}$ fine sifted lime. Mix with water to the required consistency, and lay on layers of five and six inches in thickness between the courses of brick or stones.

3. (*Ordnance.*) A short gun with a large bore, used for throwing bombs. Said to have been used at the siege of Naples in 1435, and to have been first made in England in 1543. A colossal mortar constructed by Mallet was tried at Woolwich, October 19, 1857, with a charge of 70 pounds of powder, and it threw a shell weighing 2,550 pounds $1\frac{1}{2}$ miles horizontally, and about $\frac{3}{4}$ a mile in hight.

Shells of 1,000 pounds are said to have been thrown into the citadel of Antwerp, 1832, when it was taken by the French in the war of the Revolution, 1830–32.

Mortars are constructed with a chamber of smaller diameter than the bore, for containing the charge of powder, which is poured in loose. Thin, tapering slips of wood, termed splints, are used for fixing the shell accurately in the bore, no sabot being employed.

Mortars in the United States service are divided into three classes, sea-coast, siege, and coehorn. To these may be nominally added the stone mortar, which is, however, only employed in regular sieges; none, we believe, were ever cast in this country. This and the Coehorn are of brass; the sea-coast and siege mortars of cast-iron. The two former classes are made upon the same general model, differing only in relative length and thickness of metal. The chambers of all are semi-ellipses, having their minor axes of the same diameter as the bore of the mortar.

The 13-inch sea-coast mortar (*a*) weighs 17,000 pounds, and its shell about 200 pounds.

The 10-inch light mortar (*b*) weighs about one ton, and throws a shell of 88 pounds.

The Coehorn (*c*) weighs 165 pounds, and its shell 24 pounds.

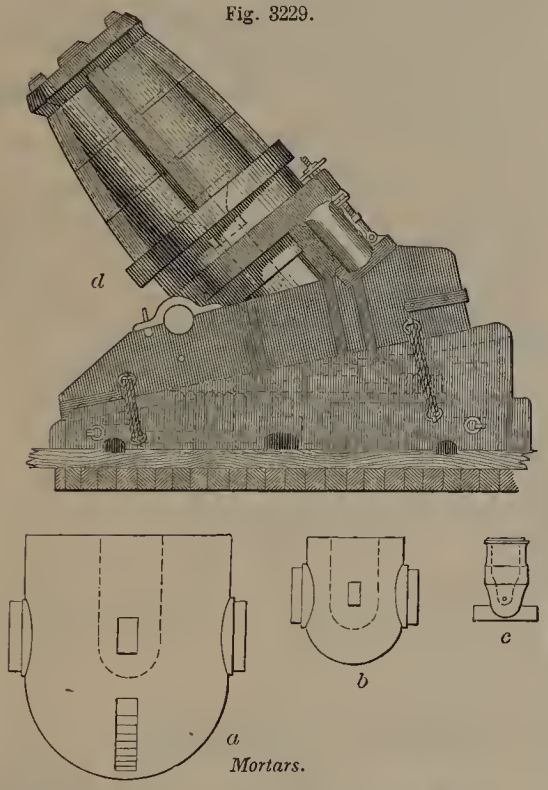
The length of bore of mortars seldom exceeds two or three calibers, and is often much less. They are intended for firing shells at high angles of elevation, generally 45°, the crushing and explosive power of their shells falling from great hights being relied on for destructive effect. They are principally used in sieges for destroying buildings, blowing up magazines, etc., and for keeping an enemy under cover within his bomb-proofs, reaching him where direct shots would fail to penetrate. Four sizes of iron mortars are used in the United States service, 8 and 10 inch "light" and 10 and 13 inch "heavy." The two former can be readily transported on wagons contrived for the purpose, and may accompany an army in the field; but the latter, in consequence of their great weight, are more particularly designed for permanent positions or for use on shipboard. The 13-inch was much employed in this way during the Rebellion, and on board the mortar-schooners fully demonstrated its efficiency, under favorable circumstances, in the operations against the forts below New Orleans. For firing, mortars are mounted on beds, at present made of wrought-iron in our service, resting on platforms of stout scantling and plank, no ordinary carriage being capable of resist-

ing the immense downward shock of even a light mortar fired at a great angle with a full charge of powder.

Stone mortars are of large caliber, from 10 to 22 inches, and have a small chamber. They are light in proportion to their size, to admit of shifting from one part of a fortification to another, and are intended for firing baskets of stones at very short ranges, or, in place of stones, 6-pounder or other small spherical case-shot may be used. They are specially designed for use in the attack and defense of fortified places when the besiegers have succeeded in establishing themselves very close to the works. We are not aware of any instance of their employment in recent warfare.

Coehorns (*c*) are small mortars, likewise intended for attacking and defending fortifications. They are made light enough to be carried from one spot to another by hand as required, and generally carry a

Fig. 3229.



Mortars.

24-pounder shell with a maximum charge of ½ pound of powder, though they are sometimes smaller.

That employed in the United States service is of brass, 24-pounder caliber, and weighs about 160 pounds. It is mounted on a wooden bed, having four handles at its sides, by which it can be readily carried by four men. It derives its name from the celebrated Dutch engineer officer Coehorn, to whom the invention is attributed. See COEHORN.

In some European services much smaller mortars than these are recognized, weighing no more than 15½ pounds, and attached to a stock.

A small mortar of this kind was invented by Captain Goodwin of the United States service, and threw a shell with great effect in an experiment at the Washington Arsenal, 1864.

Coehorns are, owing to their lightness and portability, very efficacious in dislodging an enemy from covered positions.

During a war waged by the English against some of the Maori tribes of New Zealand, about the year 1843–44, one of the native chiefs with his forces intrenched himself in a "pah" or corral on the top of a hill, whence the means in the hands of the troops failed to dislodge him. In this emergency an engineer officer was dispatched to Sydney and caused twelve small mortars to be constructed, which effectually accomplished the desired object.

These were carried by men to within a few hundred feet of the "pah" to be attacked, and pitched their shells into the heart of the camp.

With a charge of 8 ounces of powder these mortars were found capable of throwing a 5-inch shell 550 yards.

The mortar, of gun-metal, weighed 65 pounds, and the bed, of cast-iron, 28 pounds; this was fixed on a piece of 2-inch plank, 24 × 16.

When loaded, the shell projected half-way beyond the muzzle of the piece.

The chase of Mallet's great mortar (*d*, Fig. 3229) is formed of short cylinders or compound rings; the chamber being of wrought-iron let into a huge mass of cast-iron. Each of the two lower rings is composed of seven rings, and each set of these again of three smaller rings rabbeted together; the top ring consists of five rings, each composed of three smaller rings rabbeted together.

There are two light rings acting as a sort of key-ring for the six bolts or staves, the bolt-head resting on the muzzle-ring and secured with steel collars in the cast-iron mass around the breech-piece.

The weight of the whole without bed is 42 tons.
Weight of bed, 8 tons.
Weight of shell, 24 cwt.
Caliber, 36 inches.
Charge of shell, 480 pounds of powder.
Cost of shell, charged, about £25.
Length of chamber, 2 feet 6 inches.
Bore at top of chamber, 18 inches.
Bore at bottom, 14 inches.
Length to top of chamber, 8 feet.

With a charge of 70 pounds of powder, a shell weighing 2,395 pounds was thrown 2,759 yards, burying itself eight yards in the ground on its fall.

The monster mortar employed by the French at Antwerp in 1832 had a total length of 4 feet 11 inches; its outside diameter was 39½ inches; caliber, 24½ inches; length from top of chamber, 27 inches; depth of chamber, 19 inches; diameter of chamber, 9 inches. The weight of the mortar was 14,700 pounds; that of the bed, 16,000 pounds; of the empty shell, 916 pounds; and the bursting-charge, 99 pounds.

The chamber would contain about 30 pounds of powder, but 12 pounds were found to project the shell to a distance of 800 or 900 yards.

This monster affair burst with a charge of less than 20 pounds of powder after a few rounds firing.

Among the largest mortars on record are those of the island of Malta. "The rocks here are not only scarped into fortifications, but likewise into fire-engines or artillery to defend those fortifications; being hollowed out in many places into the form of immense mortars. These mortars they fill with cantars of cannon-balls, shells, stones, and other deadly materials; and if an enemy's ship should approach with a design to land, they fire the whole into the air. The effect of this tremendous invention must be very great, as it will produce a shower for 200 or 300 yards around, and would make great havoc among a debarkation of boats. A cantar is about 100 pounds weight; and as the mouths of some of these mortars are 6 feet wide, they will throw, according to calculation, 100 cantars each." — *From an account written just before the submission of the island to General Buonaparte*, 1798.

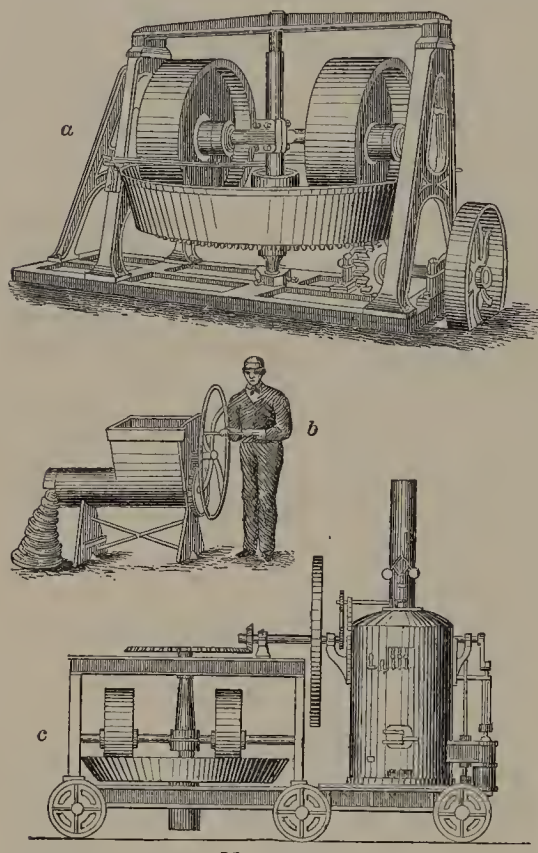
4. A short, thick candle.

Mor'tar-bed. The frame on which a mortar rests for firing.

Mor'tar-en'gine. A machine for grinding and combining materials into mortar. See MORTAR-MILL.

Mor'tar-mill. In the mortar-mill the sand, lime, and mortar are compounded together by rakes attached to the arms of a revolving wheel that moves round in a circular bed.

Fig. 3230.



Mortar-Mill.

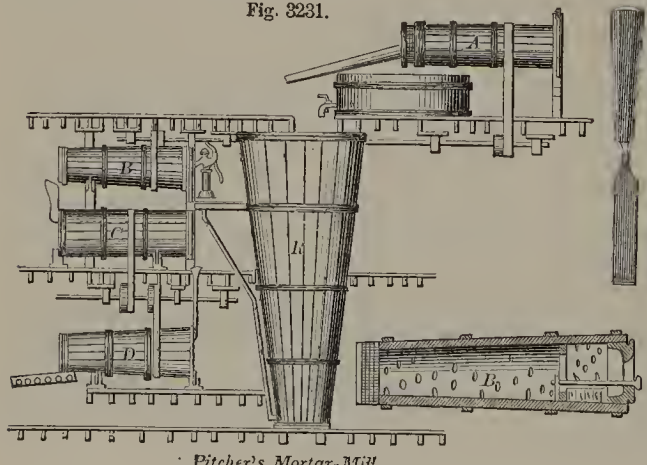
In the examples given, —

a is a large loam and mortar mill on the Chilian principle.

b is a mortar-tempering machine turned by hand-crank.

c is a mortar-mill on the same truck with the steam-engine which rotates the edge-stones in the bed.

Fig. 3231.



Pitcher's Mortar-Mill.

Fig. 3231 shows a mortar-mill on a large scale, occupying several floors of a building. The lime is slaked in a revolving barrel *A*, and discharged into a settling-vat. From this the "paste" passes to the curing-vat *R*, and is pumped thence into the upper one of three mixing-cylinders *B C D*. These revolving cylinders are slightly tapering, and have teeth on their inner surfaces, which mix the materials and gradually forward the mortar to the discharge end. It passes from one cylinder to another in the series, and from the lower cylinder *D* into the discharge-chute. The machine occupies three floors in a building.

Mor'tar-ves'sel. (*Vessel.*) A small vessel having a relatively wide beam for carrying a heavy mortar amidships. Formerly the vessel used was a *ketch;* hence, *bomb-ketch.*

Mor'tar-wag'on. A vehicle to transport a mortar and its bed.

Mor'tise. A cavity (*a b c d*, Fig. 3232) bored and cut into timber or other material to receive a *tenon.* It is the usual mode of joining the timbers of a frame, whether of a house or a machine.

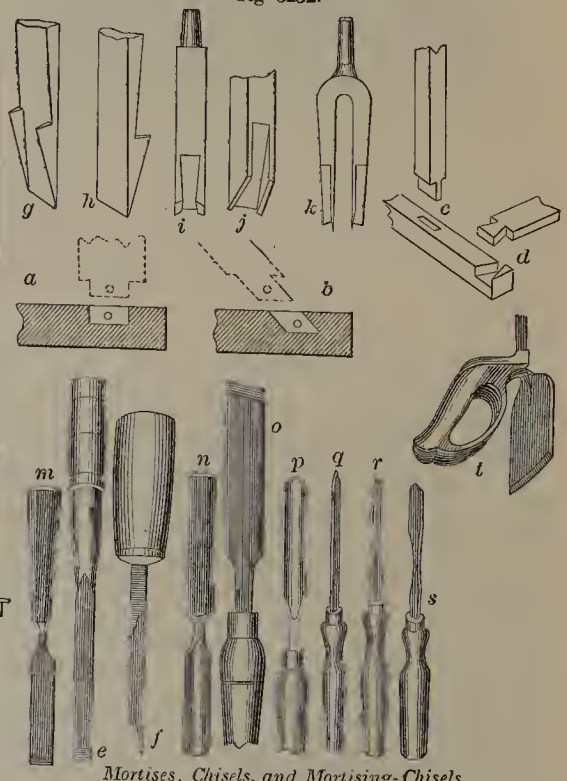
A lock made to slip in a mortise made in the edge of a door is a *mortise-lock.*

A wheel made with holes in its periphery to receive wooden cogs is a *mortise-wheel.*

Mortises in a hub are said to be *dodging* when they *dodge* in and out alternately, in order to spread the bases of the spokes and thus stiffen the wheel. The spokes are then said to be *staggered,* and the wheel is a *staggered* wheel.

Mor'tise-bolt. One let *into* a mortise in a door, instead of being placed *thereon.*

Fig 3232.



Mortises, Chisels, and Mortising-Chisels.

Mor'tise-chis'el. A stout chisel (*e f*) driven by a mallet, and used to make mortises in framing. The smaller varieties have tangs, and the larger, sockets. The *firmer* and *turning* chisels, *m* to *s*, are introduced to show the difference. *t* is a hand-adze used in dressing

tenons. *g h* are two views of the chisel of the mortising-machine, having side-wings which cut the sides of the mortise a little in advance of the chisel edge. It is the invention of Brunel or Maudslay, being applied in the mortising-machine invented by the former and constructed by the latter in Portsmouth Dock-Yard, England, in 1802–8. (See Fig. 3240.) *i j* are mortising-machine chisels whose lips are so formed that the chisel, on being withdrawn, clears the mortise of the core or chips.

The chisel *k* is a double one, each limb having two lips, adapting the tool to cut a double mortise.

Mor'tise-gage. A scribing-gage with two sharp, adjustable points, which may be set to the distance for the mortise or tenon from the working-edge, and also the width of the mortise and size of tenon.

Mor'tise-joint. A joint made by a mortise and tenon.

Mor'tise-lock. (*Locksmithing.*) A lock adapted to be inserted into a mortise in the edge of the door, so as only to expose the *selvage* or edge-plate.

Mor'tise-lock Chis'el. A joiner's chisel for making the holes in door-stiles to hide the locks. It has a peculiar shape, in order to pull out the wood.

Mor'tise-wheel. A wheel having holes to receive wooden teeth, either on the edge or face, as the case may be. Such a tooth is specifically known as a *cog*.

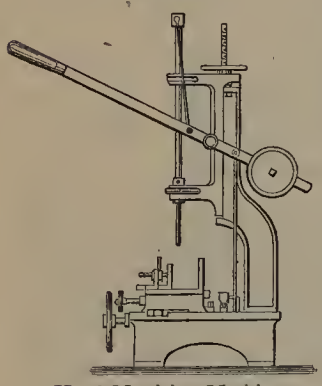
Fig. 3233.

Mortise-Wheel.

Mor'tis-ing-ma-chine'. The self-acting mortising-machine was invented by General Bentham, and described in his specification of 1793. He made them for the British Admiralty previous to 1800. His description includes the operation by means of a hole previously bored and then elongated by a vertically reciprocating chisel; and also the making of a mortise by a rotary cutter during the traveling of the work. One form included a pivoted table. He also invented double or forked mortise-chisels.

Fig. 3234 is a hand mortising-machine, having a vertically sliding bar carrying the cutter and moved by a counterbalanced lever. The work is clamped in the sliding table beneath, and is advanced by a hand-feed.

Fig. 3234.

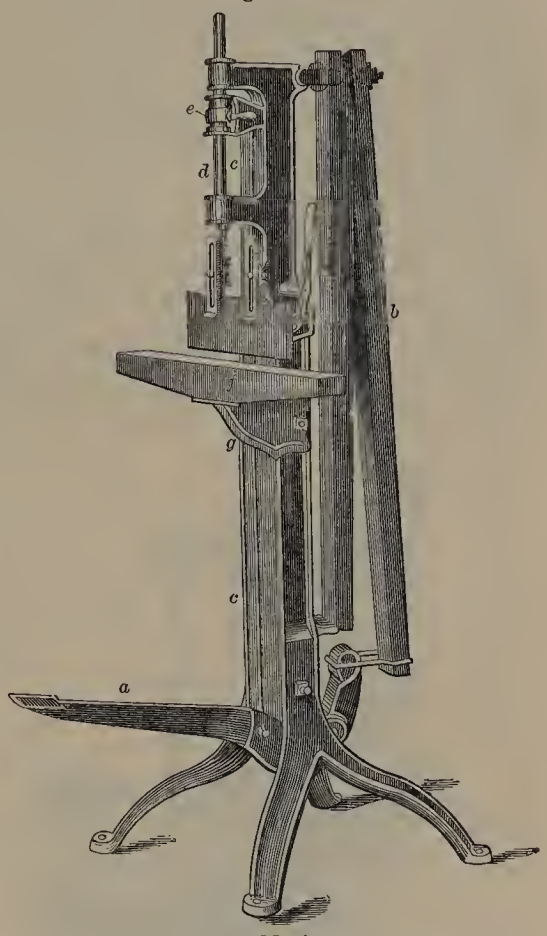


Hand Mortising-Machine.

Fig. 3235 is a foot mortising-machine, in which the treadle *a* works on a pin in the cross-brace, being connected to the wooden spring *b* by an iron strap at the back, and with the spindle *d* by the rod *c* in front; the chisel is held in a socket at the bottom end of the spindle, with which it is reversed by the handle *e* on the slide; the wooden rest *f* is screwed to an iron one *g*, which slides on the frame perpendicularly, and is secured to it by a bolt; the guide-plate is moved back and forward to adjust for the thickness of the stuff, and has stops to prevent the work from rising with the chisel.

In operating, the foot is pressed upon the treadle, which carries the chisel into the stuff to the required depth; when the pressure is relieved by raising the foot, it is withdrawn by the spring, and being lipped brings the chip out; after cutting far enough one way, reverse the chisel and finish the mortise to the required length.

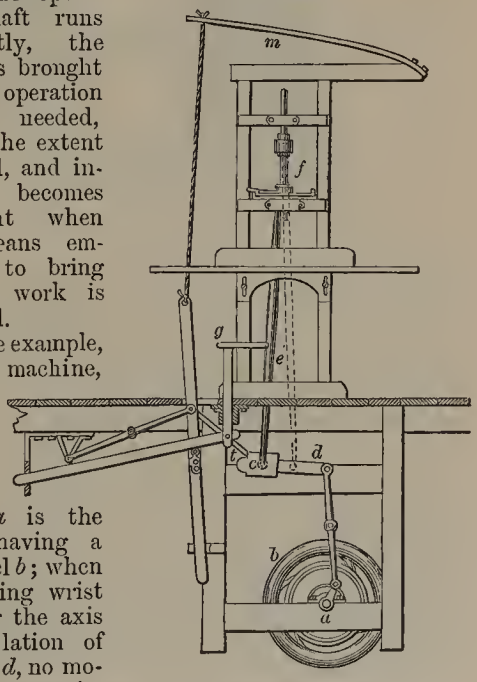
Fig. 3235.



Foot-Mortiser.

Fig. 3236 is an example of a form of mortising-machine in which, while the operative shaft runs constantly, the chisel is brought into operation when needed, and to the extent required, and instantly becomes quiescent when the means employed to bring it into work is removed.

Fig. 3236.



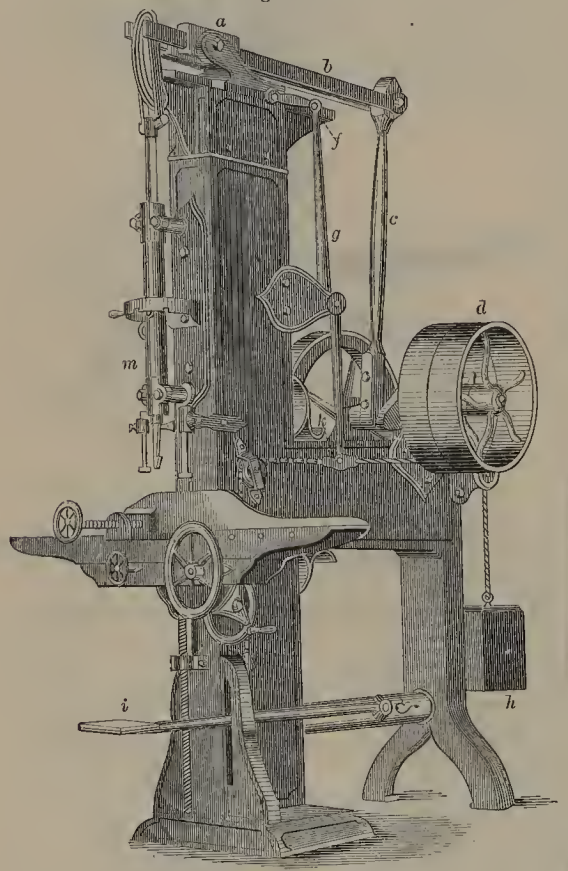
Guild's Mortising-Machine.

In the example, Guild's machine, 1852, *a* is the shaft, having a fly-wheel *b*; when the sliding wrist *c* is over the axis of oscillation of the arm *d*, no motion is transmit-

ted to the pitman *e*, which operates the chisel-stock *f*. When the treadle *g* is depressed, the sliding wrist *c* is driven out on the arm and partakes of its motion, the chisel being thereby reciprocated to a degree proportionate to the depression of the treadle, and the consequent distance of the wrist from its axis of oscillation. The spring *m* restores the wrist to its position of quiescence.

In Fig. 3237, the working parts are supported upon a strong iron frame, at the top or upper end of which are guides *a*, upon which is a slide having pivoted in it a collar through which is passed the lever *b* that operates the chisel-stock *m*. This lever is itself operated by a pitman *c* from a transverse crank-shaft at the rear end of the frame, and rotated by pulleys *d*. The slide is connected by a link *f* with the upper end of a vertical lever *g*, the lower

Fig. 3237.



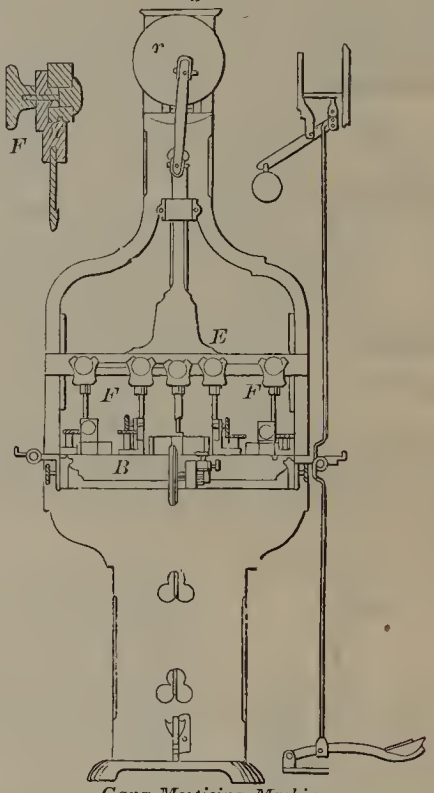
Bartlett's Power Mortising-Machine.

extremity of which is attached to a horizontal chain *k* passing over two supporting pulleys. The rear end of this chain has a weight *h* secured to it, and the forward end being passed downward is connected to a treadle *i* in such manner that by depressing the treadle the vertical lever will be caused to move the slide, and consequently the fulcrum of the chisel-operating lever, farther back, of course increasing the length of the forward arm of such lever, and consequently the stroke of the chisel-stock and its chisel. On releasing the treadle, the weight reverses the movement of the vertical lever, and throws the slide forward so that the stroke of the chisel-stock is reduced to almost nothing. By thus changing at will the fulcrum of the chisel-operating lever, the chisel may at any time be made to cut to any required depth, and when desired may be thrown out of operation, by the agency of the weight, without stopping the motion of the crank-shaft or interfering with the belt that drives the machine.

The table at the front of the machine for holding the stuff under the chisel is made compound, so that the stuff may either be moved along by hand or be held firmly upon the table and fed along as required by the hand-wheel operating the carriage or upper portion of the latter. The table is made adjustable vertically by means of a screw, and is pivoted and attached to its immediate supporting parts in such a way that it may be tilted, with one end or the other depressed to any desired angle, and there retained; the object of this being to enable the ends of the mortise to be cut at any required bevel or angle to suit the exigencies of various kinds of work.

Fig. 3238 is a gang mortising-machine. It has a set of chisel-holders *F F*, adjustable as to relative distance on a horizontal bar *E*, which is reciprocated by the wrist-wheel *r*. The work is clamped on the

Fig. 3238.



Gang Mortising-Machine.

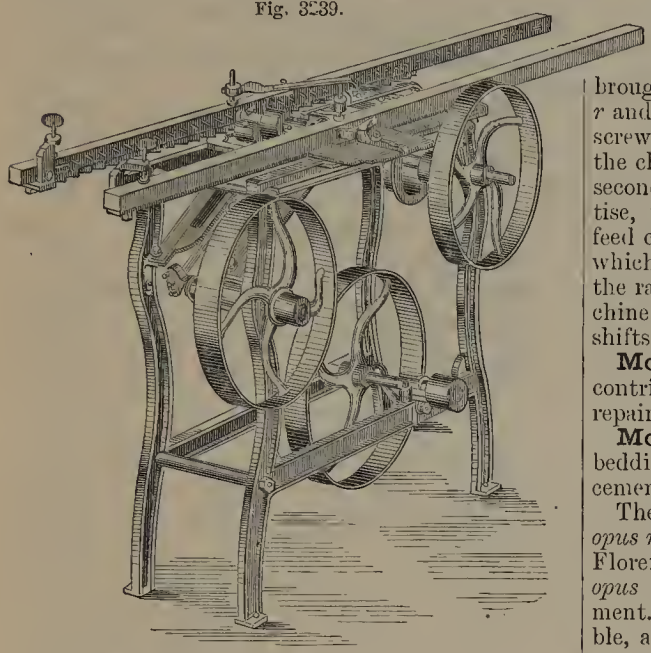
bed *B*, which has the requisite feed-motions. The chisel-holders are provided with projections that fit in a slot in the cross-head, and also with tongues fitting into grooves on the lower side of the same. They are held in place by a bolt passing through the chisel-holders and the slot in the cross-head, which is secured by a thumb-screw.

The mode of clamping the chisel-holders to the bar is shown in the smaller detached figure.

Buck's machine for boring and mortising the stiles of blinds is automatic in its operation, and either bores the round holes for the reception of the pivots of turning slats or mortises the recesses for the reception of the ends of those slats designed to be permanently fixed at a certain angle. The latter are made on this machine by means similar to those used in boring a simple round hole, the tool being a reciprocatory or traversing burr or bit, which can be used on knotty pine and other obstinate descriptions of wood where ordinary machine-chisels fail. The

machine is self-operating in all its parts. The workman puts in the stiles and sets the machine in motion, when it does its work, and, having done it, stops.

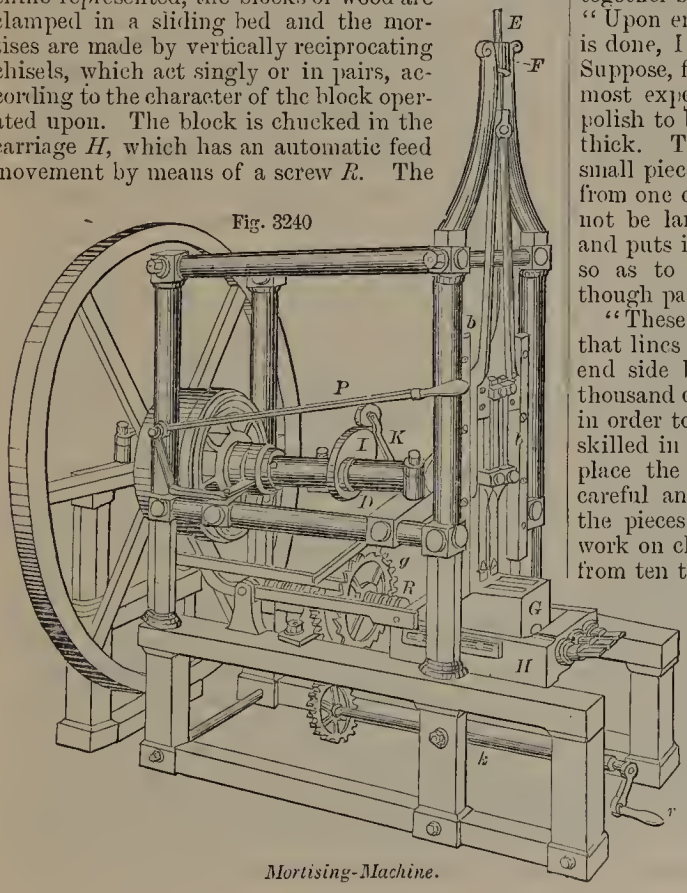
Fig. 3239.



Machine for boring and mortising Stiles of Blinds.

Fig. 3240 shows Brunel's mortising-machine made by Maudslay for the British Admiralty, about 1804, for mortising the shells of ships' blocks. The series of machines for making blocks is described under BLOCK-MAKING MACHINE. In the mortising-machine represented, the blocks of wood are clamped in a sliding bed and the mortises are made by vertically reciprocating chisels, which act singly or in pairs, according to the character of the block operated upon. The block is chucked in the carriage *H*, which has an automatic feed movement by means of a screw *R*. The chisels are attached to a slider *E*, which reciprocates vertically in guides *b* and a socket *F* on the summit of the frame. The slider *E* is moved by a crank-arm which is connected thereto, and attached to the axis *D*, on which are the driving and fly wheels. In starting, the block is brought to the right position by turning the handle *r* and shaft *k*, which act upon the cog-wheel *g* and screw *R* to slide the carriage *H*. The first stroke of the chisel is into the hole previously bored, and the second takes a shaving in the direction of the mortise, the feed having commenced. The automatic feed consists of an eccentric *I* acting upon an arm *K* which turns the ratchet-wheel on the screw-shaft *R*; the ratchet is turned one tooth at a time. The machine is thrown into action by the lever *P*, which shifts the band from the loose to the fast pulley.

Fig. 3240



Mortising-Machine.

Mor'ton's Slip. (*Hydraulic Engineering.*) A contrivance for hauling ships out of the water for repair. Patented in England, 1819. See SLIP.

Mo-sa'ic. 1. Ornamental work produced by imbedding different colored stones, glass, or gems in a cement.

The simplest form is the dice-shaped pavement, or *opus musivum*, of the Romans. The *pietra dura*, or Florentine work, is an amplification of the idea. The *opus tessclatum* was a tesselated geometrical pavement. The *opus sectile* was formed of slices of marble, as its name implies. The *opus vermiculatum* is an artistic rendering of the forms, lights, shades, and colors of pictures by the selection, shaping, and apposition of pieces of stone or gems of the right color.

A traveler in Italy relates that he saw a Florentine mosaic table valued at two hundred thousand dollars. It was less than six feet in diameter, but had required the work of a large number of men for fifteen years. It was ornamented with mosaic work composed of stones of different colors and shades matched together so as to form pictures. The traveler says: "Upon entering the hall where this kind of work is done, I could not doubt these enormous figures. Suppose, for instance, a thousand of the hardest and most expensive stones which will take on a high polish to be cut into pieces three eighths of an inch thick. These pieces are cut the other way into small pieces like shoe-pegs, and where the shading from one color to another is sudden, these pegs must not be larger than a needle. Now the artist cuts and puts in these, selected according to their color, so as to give the coloring wanted as distinct as though painted.

"These pieces or pegs must be fitted so closely that lines of separation will not show, and set upon end side by side like types. They claim that ten thousand different shades of color are necessary; and in order to do this kind of work a man must be as skilled in colors and shades as a painter, in order to place the colors properly, and then be the most careful and accurate of mechanics, in order to fit the pieces; and he must have patience enough to work on cheap pictures one year and on a fine one from ten to twenty years."

Some wonderful specimens of mosaic are to be seen at the Imperial works, St. Petersburg, Russia.

Roman mosaic consists of pieces of artificial enamel, in place of natural stone. The enamel is drawn out into rods of various sizes, cut into lengths, and arranged in cases something after the manner of printing type, the boxes containing each a different shade or color.

Glass mosaic is made of rods, shreds, or *hairs* of glass enamels of various colors

arranged side by side, so that their ends show the pattern. The bundle of glass rods, being cemented by heat, may be cut across, and each section show the pattern. *Filigree glass* and millefiore are of this character. Some of the ancient Egyptian beads were thus made.

The Tunbridge *wood-mosaic* of England is made of colored parallelopipeds of wood glued together so as to show a pattern at their ends or sections.

Mosaic rug-work is made by a careful selection of colored wools, which are stretched in a frame, so that a cross-section at any point will show the design. About 800,000 threads are thus held in a cast-iron box with a movable bottom. The top surface, formed by the ends of the threads, is treated with a solution of caoutchouc, and a backing of canvas similarly treated is laid upon it. The bundle of threads is then pushed up in the box by screwing up the false bottom $\frac{3}{16}$ of an inch. A section of the threads at this depth is then made by a horizontally revolving knife, and the sections of thread come off on the backing, to which they adhere, forming a nap thereon.

2. A pyrotechnic device consisting of a surface with diamond-shaped compartments, formed by two series of parallel lines crossing each other. The effect is produced by placing at each intersection four jets of fire which run into the adjoining ones. The intervals between the jets must be associated with the discharge of others, so as to keep up a succession of fires in the spaces.

Mo-sa'ic Floor. One laid in colored woods, tiles, or marbles, systematically arranged, either symmetrically or pictorially.

Mo-sa'ic Glass. Mosaic glass is formed by the association of various colored opaque or transparent rods of glass, so arranged that the ends may form patterns.

Sections being removed, the pieces are arranged for the production of a recurring pattern, or a general combination is formed by the association of a variety of separate ornaments.

A section imbedded in a bulb of transparent glass forms the *millefiore* paper-weight.

The *aggry-beads* of Ashantee are of this class, and show that at some former time the country was visited by, or had communication with, a land where glass-making was artistically practiced.

Another form of glass mosaic consists in the putting together of pieces of glass enamel of varying colors, and sawing them into rectangular prisms. See GLASS MOSAIC.

The art of glass-making, instead of being comparatively modern in the time of Pliny, had long been practiced in Egypt. The manner in which the mosaic glass was made is thus described by Dr. Abbott, referring to specimens in his collection now in the Museum of the Historical Society, New York City.

"678. Three fragments of colored glass on a card.

"No. 1 represents a star, No. 2 a lotus. These pieces are particularly interesting as examples of a curious manufacture. No. 3 more especially deserves attention, inasmuch as it explains the ingenious manner by which the ancients accomplished the work. Long sticks of glass of the desired color and form were welded together, side by side. This mass, being well united, was then sawn through transversely at regular intervals, thus producing a supply of perfectly similar patterns. The pieces thus obtained were afterward polished and inserted, like mosaic work, to decorate various utensils. Thus, for example, were produced a series of stars of exactly similar dimensions and form as No. 1, which were inserted side by side in a cavity to represent the heavens; or the ornament No. 2, representing the lotus, was thus reproduced with an exactness which no other contrivance could guarantee. The piece No. 3 has evidently been sawn from such a stick of glass as above described and broken off. They were found at Sakkarah."

Mo-sa'ic Gold. A brass used for making cheap jewelry.

Hamilton and Parker's: copper, 32; zinc, 33. Or, copper, 4; zinc, 1.

Hermstadt's: copper, 7; zinc, 1; platinum, 16. Resembles gold in color and weight. See ALLOY; MOCK GOLD.

Mo-sa'ic Pave'ment. One laid in colored tiles or slabs arranged in systematic order.

Mo-sa'ic Tile. A tile molded with different colored clays, arranged in patterns in imitation of the associated pieces of colored stones in a true mosaic.

Mo-sa'ic Wool. A form of rug or mat made from colored wool, arranged so that the ends of the wool present a definite pattern.

Threads of wool of equal length are placed horizontally in a frame, close together, to form a compact mass. They are of different colors, and the colors are arranged in conformity with a pattern. The threads, being held firmly in the frame, are then cut across to form cubical masses, all the threads in each cube being kept rigidly in their places. The cube is then placed in a frame with the threads vertical, and a clean cut made across the top. The smooth surface is then wetted with a solution of rubber, and a piece of canvas firmly attached. When dry, a machine cuts off a slice of such thickness as is desired for the length of the pile. A rug or mat of a velvety finish is thus produced. Other slices can be cut off in the same way until the wool is exhausted.

Mo'ses-seam. A sailmaker's seam, as the selvages of the canvas lap past each other. See MONK-SEAM.

Mos'lings. The thin shreds or scrapings of leather shaved off by the currier in dressing skins.

They are used in wiping off metals while grinding and polishing. Cotton waste is used in a similar manner when plentiful.

Moth'er-gate. A lateral passage where a shaft intersects a seam of coal.

Moth'er-lye. The liquid remaining after all the salts that will regularly crystallize have been extracted from a solution.

Moth'er-of-pearl Mi-crom'e-ter. The micrometer of Cavallo. A thin semi-transparent slip of mother-of-pearl, $\frac{1}{20}$ of an inch wide, is ruled with fine graduations, and mounted within the tube at the focus of the eye-lens of the telescope, where the image of the object is formed. The divided edge is brought into convenient proximity to the image.

Moth'er-of-pearl Work'ing. Mother-of-pearl is the inner coat or layer of some sea-shells, the beautiful tints of which depend upon the lamellar structure of the surface, which decomposes and reflects the light.

The structure of the pearl shell admits of its being split into laminæ, which may be used for the handles of knives, for inlaying, the manufacture of buttons, etc.; but in practice, the different parts of the shell are selected of a thickness to suit the special purposes, and the pieces are adapted by saws, filing, or by the grindstone. Square or angular pieces are cut with the circular saw or the back saw; in the former case, the shell is fed up as the saw divides it, and in the other the shell is held in a vise and the saw operated by hand. Circular pieces are cut with an annular or crown saw, which is fixed upon

a mandrel. In sawing and grinding, water is plentifully supplied to the instrument.

After the pieces of pearl shell are cut, ground, or turned to the proper form, they are finished with pumice-stone and water, while the work is held fast in a form of clamp as it is revolved in a lathe. This process may be followed by an application of ground pumice-stone applied with a piece of cork or a cloth moistened with water. The polishing is with rotten-stone, powdered chalk, or Spanish whiting, moistened with dilute sulphuric acid, which may be applied upon a piece of cork or a bit of soft wood. The acid tends to develop finely the striated structure of the shell. In some turned works fine emery-paper may be used, and followed with rotten-stone moistened with the acid, or some limpid oil instead.

The grinding or polishing material may be applied to the surface of wheels covered with cloth and moistened with water, the pumice-stone, and the rotten-stone. Sometimes dry powdered chalk or Spanish whiting is used in the place of the rotten-stone.

Pearl may be engraved in relief, by the aid of corrosive acids and the etching-point. The designs or patterns are drawn upon the shell with asphaltum varnish; strong nitric acid is then brushed over the plates repeatedly, until the parts undefended by the varnish are sufficiently eaten away by the acid. The varnish being washed off with turpentine, the device, which the acid has not touched, is found in relief.

Moth-trap. An attachment to a beehive to catch the moth, — *miller*, as it is familiarly called, — whose larva builds its web in the hive, and destroys the colony.

Some traps have slats, with intervals which are adapted for the passage of the moth, but too small for the bees. The moth runs in here for concealment, and hence their eggs are taken and destroyed Other traps are on the principle of the *cul-de-sac*, and are removable for the destruction of the tenants. Others have a liquid in which the moth or larvæ are drowned.

Mo'tion. 1. The train of wheels in a watch immediately concerned in the moving of the hands. See MOVEMENT.

2. (*Steam-engine.*) *a.* The cross-head in a locomotive.

b. The slide, slide-rod, and link of a locomotive-engine.

Mo'tion-bars. (*Steam-engine.*) Guide bars or rods.

Mo'tor. Properly speaking, — a source of motion, such as heat derived from the combustion of coal used in expanding a substance such as water or air; falling water; air in motion; dynamic electricity produced by chemical reactions or otherwise; animal strength, etc.

Technically, — a prime mover in the sense of a steam, air, or electro-magnetic machine; a water-wheel, horse-power, etc. See under those heads.

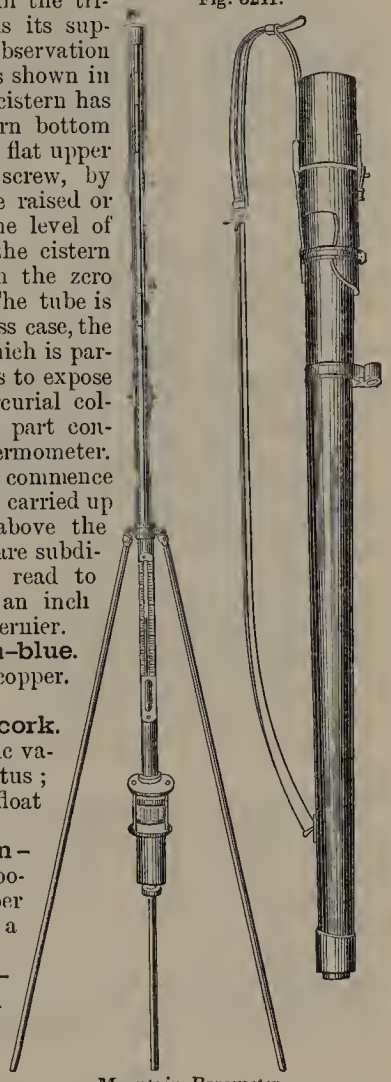
Moulde'baert. The Flemish earth-scraper. A large shovel drawn by a horse and guided by a man. A *grading-scraper*.

Mou'line; Mou'li-net. The rope-winding drum of a hoisting-machine.

Mound. (*Civil Engineering.*) A lump of original ground left at intervals to show the depth of ground excavated.

Moun'tain-ba-rom'e-ter. A portable barometer designed for measuring vertical hights above the sea. It is, consequently, more carefully made and accurately adjusted than the common barometer. That of Troughton, which is most generally known and probably the most convenient, is, for transportation, inclosed in the tripod which forms its support when an observation is to be made, as shown in Fig. 3241. The cistern has a flexible leathern bottom resting upon the flat upper extremity of a screw, by which it may be raised or lowered until the level of the mercury in the cistern corresponds with the zero of the scale. The tube is inclosed in a brass case, the upper part of which is partially open, so as to expose to view the mercurial column, the lower part containing a thermometer. The graduations commence at 15 inches, are carried up to 33 inches, above the zero point, and are subdivided so as to read to thousandths of an inch by means of a vernier.

Fig. 3241.



Mountain-Barometer.

Moun'tain-blue. Carbonate of copper. Malachite.

Moun'tain-cork. A spongy, elastic variety of asbestus; light enough to float in water.

Moun'tain-green. A carbonate of copper combined with a white earth.

Moun'tain-how'it-zer. A light field-piece, of large caliber in proportion to its weight. It is mounted on a light carriage which may be drawn by one horse.

Fig. 3242.

Mountain-Howitzer (*Ashantee Expedition*, 1873-74).

The howitzer and its carriage may each be packed on the back of a horse or mule.

The piece shown in the cut is a gun of the howitzer battery made for the negro contingent in the Ashantee war, just concluded. Sir Garnet Wolseley's dash on Coomassie is something of which to be proud.

Moun'tain-leath'er. A variety of leather with interlacing fibers producing a texture resembling leather.

Moun'tain-lime'stone. A series of marine limestone strata, below the coal measures and above the old red sandstones.

Mount'ing. 1. The setting of a gem.

2. The frame of a picture.

3. The back stiffening or support of a print or map.

4. The harness tackle of a loom.

5. The carriage and tackle of a piece of ordnance.

6. The ornamentation of the stock of a fowling-piece.

7. The fastening of a piece to be turned on the mandrel of a lathe.

8. (*Saddlery.*) In the plural, — a general term given to the metallic trimmings of harness. In England called harness furniture.

Mouse. 1. (*Nautical.*) *a.* A ball, knob, or puddening worked on a rope.

b. A turn or two of spun-yarn uniting the point of a hook to the shank to prevent its unhooking.

2. (*Blasting.*) A match used in firing guns or mines.

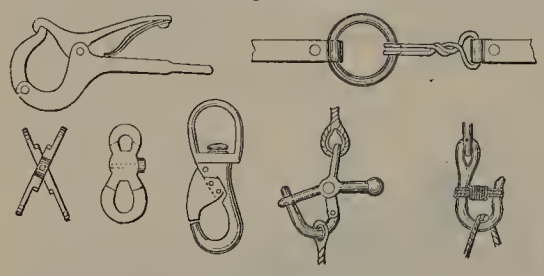
Mouse-trap. A small trap for catching mice. (See ANIMAL TRAP.) Pepys in his Diary, 1661, mentions purchasing two mouse-traps on his way home.

Mous'ing. 1. (*Loom.*) A ratchet movement in a loom.

2. (*Nautical.*) A lashing or latch connecting the bill with the shank of a hook.

Mous'ing-hook. A hook secured by a mousing passing around its two branches and closing its

Fig. 3243.



Mousing-Hook.

mouth, in order to prevent it from straightening out when supporting a heavy weight or to obviate the danger of unshipping.

Fig. 3243 shows several forms : —

One has a mousing of cord, by which the bill of the hook is secured to the shank.

Next to it is one with a retaining and releasing hook.

Above is a pair of hooks engaging in different directions, one forming a mousing for the other. *Sister-hooks.* A snap-hook.

On the left, below, are views of a watch-chain or brequet hook, having portions which open on a swivel.

Also a hook having a mousing-block of caoutchouc.

Above is a gravitating mousing-link which throws off from the point when the load on the hook is suddenly lightened, as in the case of the hooks of davit-fall blocks.

Mousse-line'. French muslin.

Mouth. 1. An opening by which a vessel is filled or emptied ; if it have a turned-over edge, such is called a *lip.*

2. The muzzle of a fire-arm.

3. The opening of a vice between its *chops, chaps, cheeks,* or *jaws,* as they are indifferently termed.

4. (*Metallurgy.*) *a.* The charging opening of a furnace.

b. The hole in a furnace out of which melted metal flows.

5. The cross-bar of a bridle-bit ; uniting the branches or the rings, as the case may be.

The *mouth* gives character to the bit as the *straight* mouth-piece, or *arched, scvere, jointed, wired, clothed,* or *with rollers,* as the case may be.

6. (*Music.*) *a.* The opening in an organ pipe whence the wind emerges. Being directed against the *lip* or *wind-cutter,* it acquires a vibration which is imparted to the column of air in the pipe, producing a musical sound. The principle of the flageolet is similar.

b. In a flute, — the edge of the opening against which the air from the mouth of the performer is cut, the vibration thereby imparted being communicated to the column of air in the tube. The *pitch* depends upon the length of the tube beyond the mouth, and the holes allow the length to be varied so as to produce varying notes. See PIPE.

7. (*Fortification.*) *a.* The outer or widest part of an embrasure. The narrow part is the *neck.*

b. The part of a trench most remote from the besieged place.

8. (*Joinery.*) The slot in a plane to receive the bit.

Mouth-gage. (*Saddlery.*) A device for measuring a horse's mouth, consisting of a gage which answers as the mouth-piece, a stationary cheek-piece on one end, and a sliding cheek on the other, with a set screw to hold it in any desired position. On the lower arm of the sliding cheek there is another slide held to its place by a set screw. The first slide is used to obtain the exact width of the horse's mouth ; the slide on the lower arm of the sliding cheek is used to measure the hight of the bar of the mouth, each of the bars being gaged in inches and fractions.

Mouth-glass. (*Dentistry.*) A dentist's small mirror for inspecting the teeth and gums.

Mouth-piece. (*Music.*) 1. The part of a wind-instrument applied to the lips.

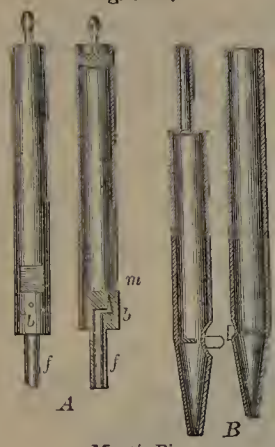
2. (*Saddlery.*) That part of the bit which is placed in the horse's mouth.

Mouth-pipe. (*Music.*) *a.* The part of a musical wind-instrument to which the mouth is applied.

b. An organ pipe having a lip to cut the wind escaping through an aperture in a diaphragm. See FLUTE-ORGAN.

The *mouth-pipe* is similar to the *flageolet.* In the *wooden* mouth-pipe *A* of the organ it is a cylinder or a parallelogram ; in the latter case, the inside sectional dimensions are as 4 to 5, the interior surface being smoothed by an application of size. The pitch of the note depends upon the length of the pipe above the mouth. The upper end may be open, or stopped by a *tampion,* which fits air-tight. The lower end is closed by a block on which three of the walls of the pipe are glued. The front wall terminates in a sharply beveled edge at the lower end, just above the block *b,* the space forming the mouth *m,* and the edge itself the *lip* or *wind-cutter.* The wind-pipe *f* from the bellows is attached to the block *b.* A block is fastened to the walls of the pipe, leaving an intervening space between which the wind passes

Fig. 3244.



Mouth-Pipes.

to the mouth. The aperture is called the *plate of wind*, and the sheet of air issuing therefrom is cut by the sharp edge or lip at the lower end of the front wall, the vibrations caused thereby being communicated to the column of air in the tube and producing a musical note. See PIPE.

The *metallic* mouth-pipe *B* differs from the wooden one, not alone in the material, but in the construction. The lower end is diminished so as to meet the size of the pipe which conducts the wind from the bellows, and at a point opposite the *mouth*, or slit in the front of the tube, a *languette*, or plate, is placed, nearly closing the interior area of the pipe. Between the *languette* and the under lip a *plate of wind* is formed, the stream of air from which impinges upon the upper lip, and the vibration thus imparted is communicated to the column of air in the pipe.

At each end of the slit or mouth is a soft-metal lug which is called an ear, and is bent more or less over the mouth to modify and qualify the tone.

One of the figures shows a pipe at whose upper end is a smaller, open pipe; this is termed the *chimney-top*, and the partial opening thus afforded has the effect of *sharping* the note. The same effect in kind, if not in degree, is attained by making a hole in the *tompion*.

Mouth-spec'u-lum. (*Surgical.*) *a.* An instrument for depressing the tongue and raising the soft palate to expose the posterior fauces.

Fig. 3245.

Mouth-Speculum.

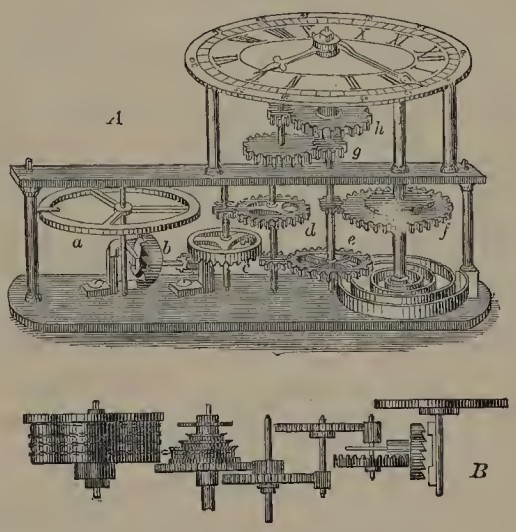
b. A frame to keep the jaws apart while operating in the mouth.

Mov'a-ble Lad'der. A form of *man-engine* for ascending and descending shafts. See MAN-ENGINE.

Move'ment. (*Horology.*) The going mechanism of a watch or clock. The motor, train, regulator, and indicator of time.

In Fig. 3246, *A* is a view of a watch-movement with vertical escapement, the barrel containing the mainspring and the fusee being removed. *B* is an elevation of a movement, barrel and fusee in place. In the lower right-hand corner (upper figure) is the mainspring, one end of which is fast to a pillar and the other to the winding-stem, which carries a ratchet-wheel provided with a click, and also the spur-wheel *f*. When the watch is wound up, the spring is condensed, and through the medium of the click operates to rotate the winding-stem, the wheel *f* on which turns a pinion and through it the wheel *e*, which gears with a pinion, causing the movement of the wheel *d*, rotating a pinion on the shaft of the crown-wheel *c*, which turns the pinion of the scape-wheel *b*. The teeth of this are alternately engaged by and released from two pallets on the axis or *verge* of the balance-wheel *a*, causing it to oscillate back and forth to an amount determined by a stop, so as to perform a uniform number of oscillations in a given time, thus regulating the movement of the works. The shaft of the wheel *e* is prolonged upwardly, and, passing through the hollow shaft of the wheel *h*, carries the minute-hand at its

Fig. 3246.



Watch-Movement.

upper end. It also carries a pinion *g*, which engages a wheel on an upright shaft, turning a pinion which gears with the wheel *h* on the hollow shaft that carries the hour-hand. The number of teeth in the various wheels and pinions bear such relations to each other, that when the balance-wheel and escapement are in adjustment, the minute-hand shall be carried around the dial in exactly one hour, while the hollow shaft of the wheel *h* rotates but $\frac{1}{12}$ as fast, carrying the hour-hand round but once in 12 hours.

Mow. (*Husbandry.*) A bay or large compartment of a barn in which hay or sheaves of grain are stored ready for thrashing.

Mow'er. (*Husbandry.*) A machine for cutting grain or clover. A great many devices were used before a satisfactory conclusion was reached. Plate XXX. shows a large number of distinct inventions, involving reciprocating and circular movements of single knives and knives working in apposition. The illustrations and group headings will be readily understood, and the dates will add interest to the list, showing the length of time that man has been hammering at the problem. The harvester used in the plains of Rhætia, in the time of Pliny, had no proper motion, but was simply a comb whose teeth had sharp edges which cut and tore the head of the grain from the stalk and allowed it to be brushed into the box of the machine. See REAPER; CLOVER-HARVESTER.

Mowing was a familiar duty in Palestine, and the Scripture references to it show that the ardent sun cured the grass in a short time, as with us. The sudden wilting and quick drying which form the basis of so many beautiful comparisons in the Bible are more descriptive of the Syrian or American hay harvest than that of England, where persistent spreadings and turnings are the order of the day.

Moses and David use the similitude: —

"In the morning it flourisheth and groweth up; in the evening it is cut down and withereth."

"For we are *consumed* by thine anger."

"My heart is *smitten*, and withereth like grass."

The uses of hay in Palestine are nearly forgotten. The *tibn* of the Arabs, the ordinary fodder for cattle and horses, consists of straw. It is sometimes cut and mixed with barley. Chaff, or the husks of grain, is also used.

The most ordinary classification of mowers is the apparent one, *two-wheeled* or *one-wheeled*. The former of these is shown in Figs. 5, 8, 9, 11, 14, 16, of Plates XXXI., XXXII.

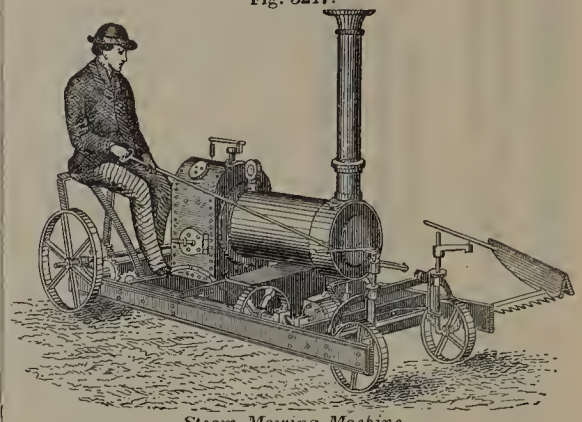
A one-wheeled mower is shown at Fig. 1, Plate XXXI.

Another distinction is the mode of attaching the finger-bar to the frame, *rigidly* or by a *hinge*. The former of these is shown in Figs. 1, 2, 3, 4, Plate XXXI., the different figures having distinguishing features. Figs. 5 to 12 inclusive show various adaptations of the hinged finger-bar.

Another distinction common among those who use the machine is the position of the cutter-bar in point of degree of advancement relatively to the driving-wheels. These positions are known as *front-cut*, *center-cut*, *rear-cut*; that is, before the driving-wheel, even with the axle, rearward of the driving-wheel. The first is shown in Figs. 2, 5, 9, 10, 11, 15, 16, 21, of Plates XXXI., XXXII., XXXIII.; the second in Figs. 1 and 7, Plate XXXI.; the last in Figs. 4, 6, 8, 13, 19, of Plates XXXI., XXXII.

Several modes of draft also furnish peculiarities worthy of notice. The *center-draft*, as in Wilber's patent, in which the cutter-bar stretches across the width of the driving-gear. The *side-draft*, in which the cutter-bar projects laterally, so that the horses walk in the swath previously cut, not tramping in the standing grass. This feature is shown in most of the figures in the Plates. One other mode of draft

Fig. 3247.



Steam Mowing-Machine.

is to be noticed, and that is the *propeller*, in which the cutting apparatus is ahead of the horses, which push the implement before them. This is the original form, it may be presumed, and was used in Gaul eighteen centuries since (see figure under the subject REAPER). The form still survives in the CLOVER-HEADER (which see). Reapers have other features, such as *reels*, *rakes*, *droppers*, etc., and are considered under REAPER.

Classification of Mowers by Structural Features.

The numbers refer to corresponding numbers in Plates XXXI, XXXII, XXXIII.

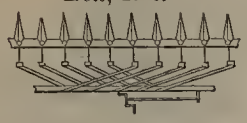
MOWERS.

- Connection of cutting apparatus with frame
  - *Finger-bar rigidly connected*
    - To main frame . . . 1
    - To hinged coupling-frame . . . 2
    - To vertically sliding frame . . . 3
    - To flexible coupling-arms . . . 4
  - *Finger-bar hinged*
    - To arms rigid with main frame . . . 5
    - To two arms; one rigid, the other jointed . . . 6
    - To two arms, both jointed . . . 7
    - To a single swiveled bar . . . 8
    - To a coupling-frame jointed to main frame . . . 9
    - To coupling-frame jointed to secondary hinged frame . . . 10
    - To coupling-frame vibrating on main axle . . . 11
    - To sliding arms . . . 12
- Mode of driving cutters . . . .
  - By simple gearing . . . 13
  - By friction gearing . . . 14
  - By planetary gearing . . . 15
  - By gyrating gearing . . . 16
  - By screw gearing . . . 17
  - By changeable-speed gearing . . . 18
  - By cams . . . 19
  - By belts . . . 20
  - By piston moved by compressed air . . . 21
- Style of cutters . . .
  - *Reciprocating*
    - *Rectilinear*
      - Single blade . . . 22
      - Transversely divided blade . . . 23
      - Double blades . . . 24
    - *Curvilinear*
      - Blade hung upon hinged arms . . . 25
      - Series of pivoted knives . . . 26
  - *Rotary* . . . .
    - Cutters upon single vertical shaft . . . 27
    - Cutters upon single horizontal shaft . . . 28
    - Cutters upon series of vertical shafts . . . 29
    - Cutters upon endless chain or belt . . . 30
- Dividers . . . .
  - *Rigid*, 31.
  - *Adjustable* . . . .
    - Vertically . . . 32
    - Horizontally . . . 33
  - *Hinged* . . . .
    - To move vertically . . . 34
    - To move horizontally . . . 35
    - To move axially . . . 36
- Track-clearers.
  - *Rigid with cutter-frame.*
- Draft . . . .
  - *Jointed* . . . .
    - Upon main axle.
    - Upon cutter-frame in rear of axle { Above. / Below.
    - Upon cutter-frame in front of axle.
  - *Independent of tongue.*

Reciprocating and Advancing.

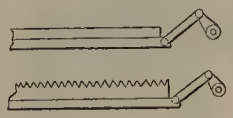
Ancient Roman.

Bell, 1826.

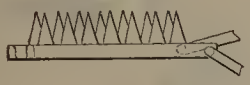


Manning, 1831.

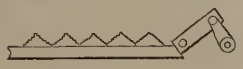
Mc Cormick, 1834.



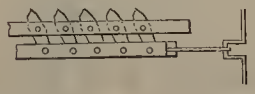
Rundell, 1835.



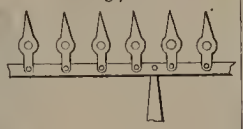
Mc Cormick, 1850.



Stacey, 1852.



Ridley, 1852.

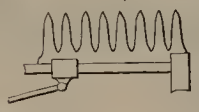


Randell, 1852.

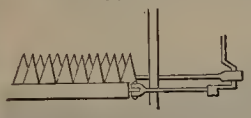
Mc Cormick, 1852.

Dray, 1852.

Fowler, 1852.



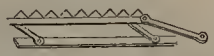
Wray, 1852.



Harkes, 1852.

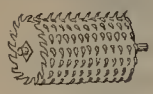
Gompertz, 1852.

Fountain, 1849.

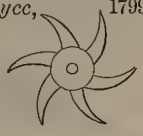


Rotary and Advancing.

Pitt, 1786.



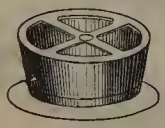
Boyce, 1799.



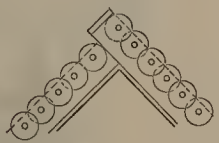
Walker's Phily. 1799.

Gladstone, 1805.

Smith, 1811.



Cumming, 1811.



Dobbs, 1814.

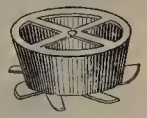
Scott, 1815.

Mann, 1820.

Budding, 1830.

Phillips, 1841.

Gibbon, 1846.



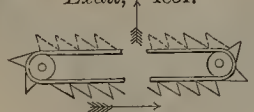
Whitworth, 1849.

Fairless, 1841.

Winder, 1851.

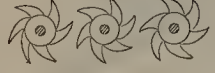
France, 1851.

Exall, 1851.

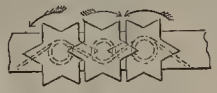


Mac Kay, 1851.

Mason, 1852.



Smith, 1852.



Gompertz, 1852.

Gompertz, 1852.

Burch, 1852.

Trotter, 1851.

PLATE XXX. CUTTING APPARATUS OF HARVESTERS.

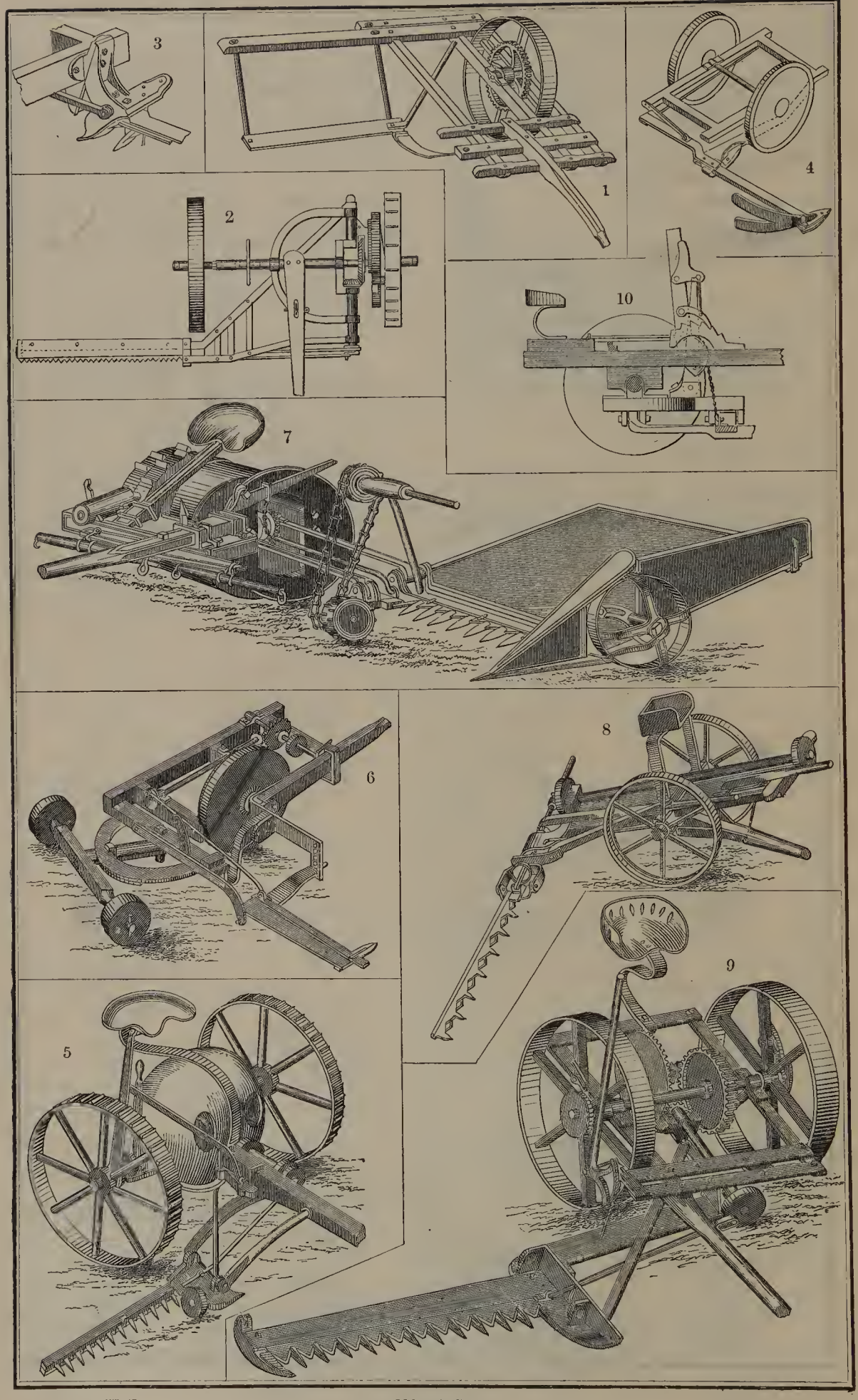


PLATE XXXI. MOWERS.

Showing Modes of connecting the Cutting Apparatus with the Frame.

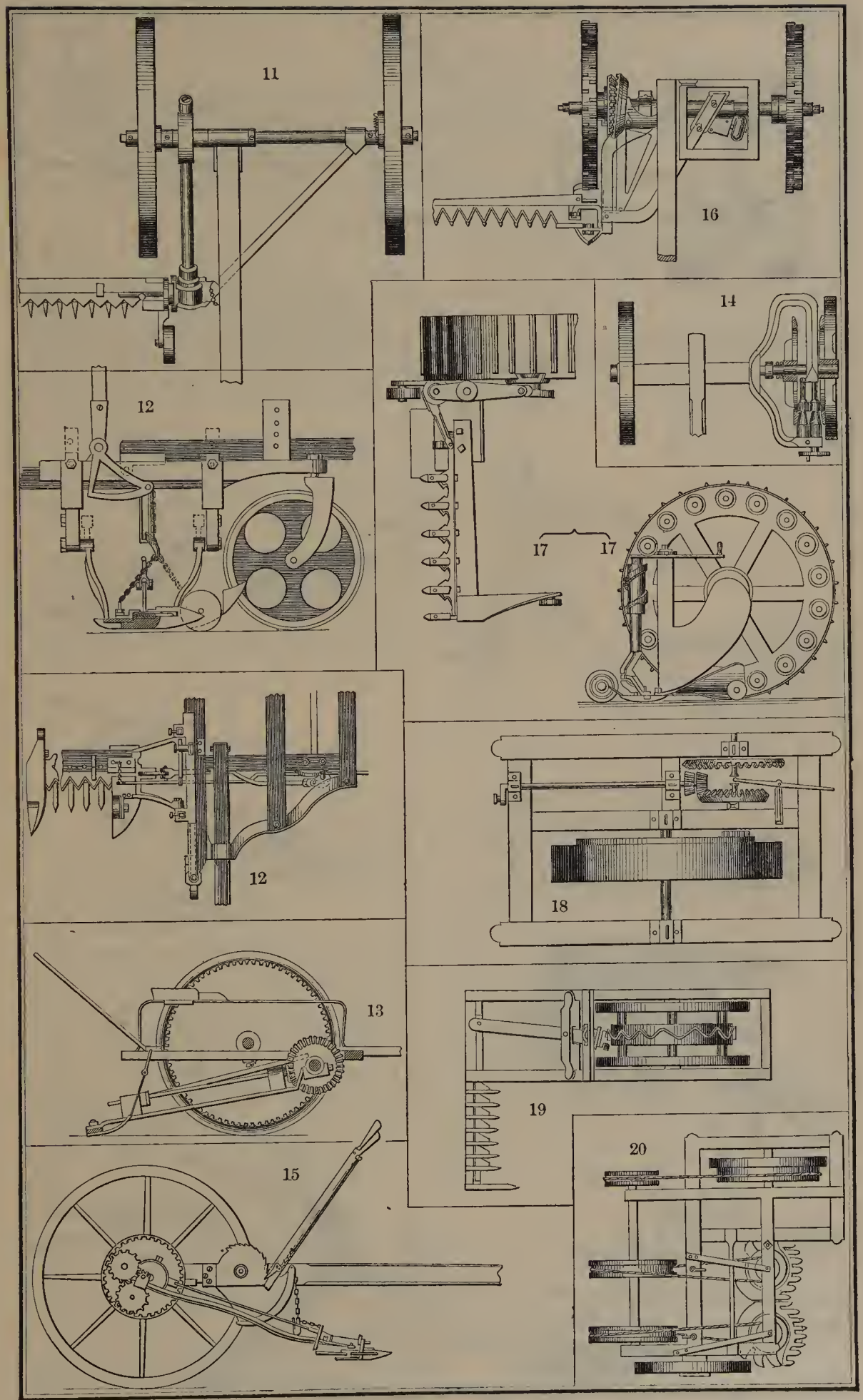
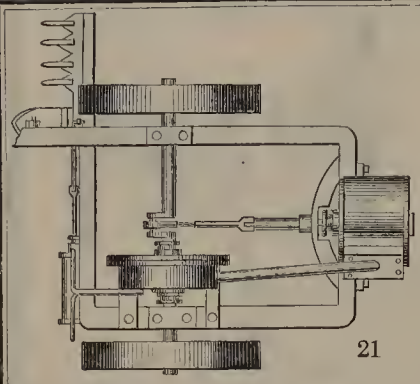


PLATE XXXII. MOWERS.

Showing (11, 12) *Modes of Connection of the Cutting Apparatus with the Frame;* (13–20) *Modes of driving Cutters.*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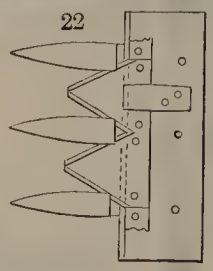
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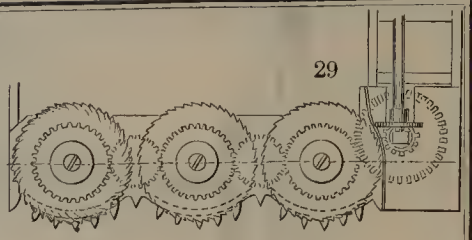
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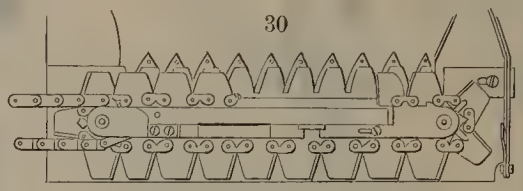
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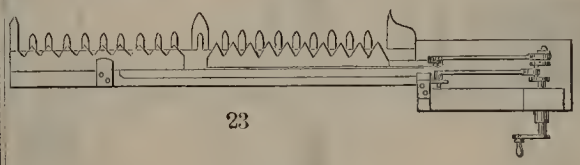
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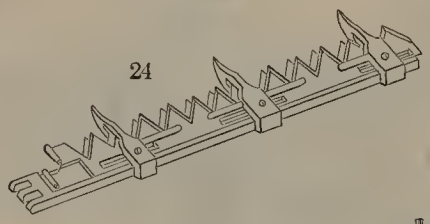
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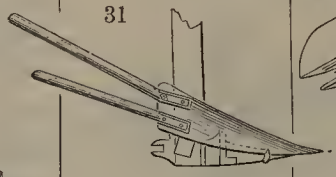
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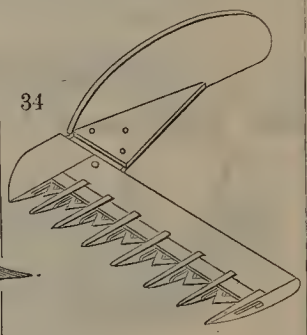
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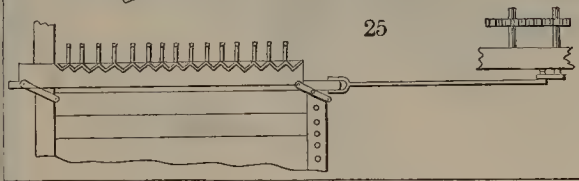
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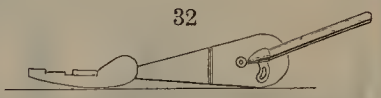
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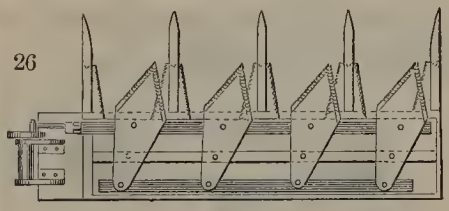
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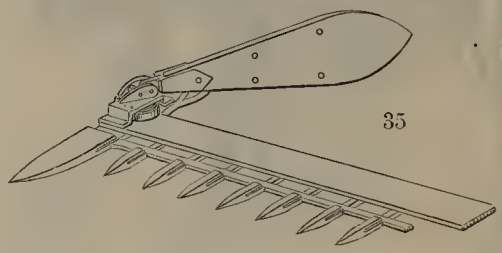
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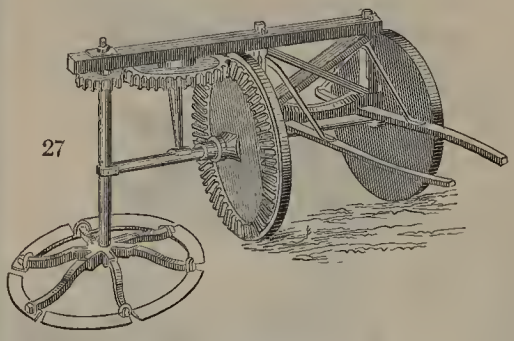
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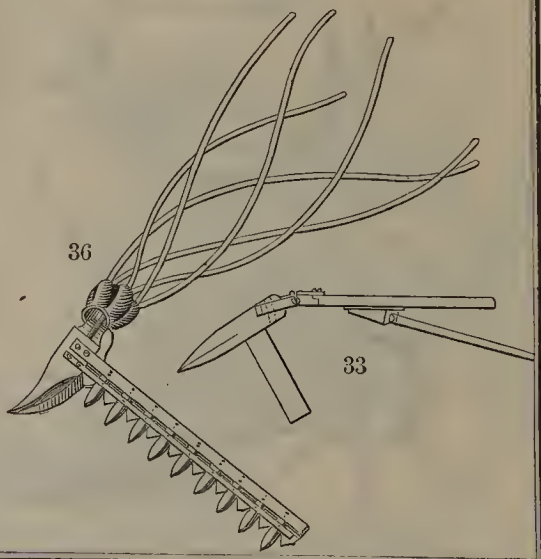
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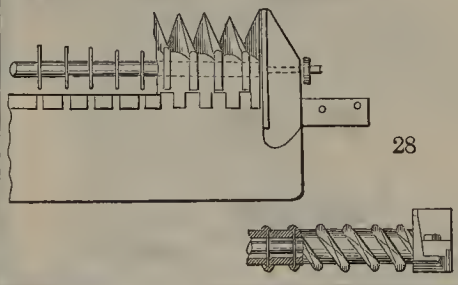

28

PLATE XXXIII. MOWERS.

Showing (21) *Mode of driving Cutter*; (22 – 30) *Styles of Cutters*; (31 – 36) *Track-Clearers.*

In Fig. 3247 a steam-engine is shown as adapted to operating the implement.

In some parts of Solano County, California, where the grain and grass are very short, an apron is fitted under the sickle of the mower, which catches all the grass, and when full dumps it in piles. Grass and grain not over three inches in hight are thus secured, in some cases at the rate of a ton to an acre.

The smallest description of mower is that for mowing lawns, which is pushed by the gardener so as to cut the grass before it is tramped.

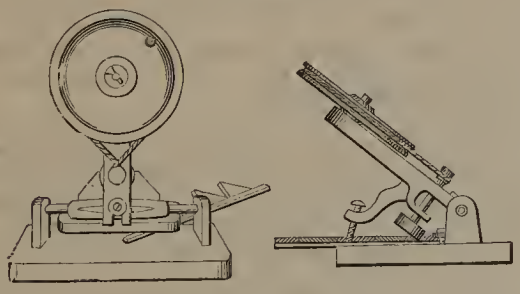
It weighs about 30 pounds and cuts a swath of 10 inches. The cylinder has spiral knives, and is rotated by gear connection to the wheels of the machine. These spiral blades cut against the rectilinear edge of a stationary knife, which is set at a tangent to the cylinder. The grass is nipped between the blades and swept into a trough in the rear, which carries it until sufficient has accumulated to render it advisable to empty. The grass is kept short by frequent cuttings. See LAWN-MOWER.

The classification just given concerns many parts common to *mowers* and to *reapers*, which are included under the generic title *harvesters;* the latter also embraces many other machines for cutting crops, such as beans, corn, cotton, hemp, etc. For a list, see HARVESTER.

The features appertaining to grain-harvesters proper, such as rakes, reels, droppers, binders, etc., are classified and considered under REAPER (which see).

Mow'ing-ma-chine' Cut'ter Grind'er. A grindstone or emery-wheel arranged and adapted for grinding the knives of mowing-machines. The example is a portable implement to be placed on a bench or stool. The cutter-bar is clamped to the base-plate, being guided to position by the angular projection on the adjustable bed-piece, and the emery-stone acts upon the teeth as they are consecutively brought into position beneath it. The emery-stone frame has oscillation in a vertical plane, to bring it down to or away from its work, and has also a longitudinal movement, to pass along the edge of the cutter.

Fig. 3248.



Mowing-Knife Grinder.

Mox'a. (*Surgical.*) A substance burnt on the skin to form an ulcer. The soft, woolly leaves of the artemisia are used. Dr. Brown-Sequard repeatedly applied moxas to the back of our late Senator Sumner. He regarded the treatment as the most severe he had ever applied to any living creature, — not excepting his guinea-pigs, which, in various states of dilapidation and destitution of limbs and nerves, were all eaten by the Parisians during the siege.

Mo'zam-bique'. (*Fabric.*) An open dress-goods having a chain in which the cotton threads are associated in pairs, and the woolen filling is soft and fleecy. It is dyed in the wool, self-colored, or striped in the warp.

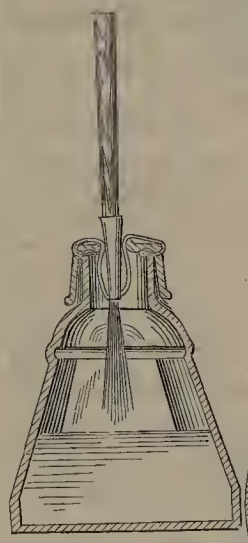
Moz'ing. Gigging of cloth.

M-roof. (*Carpentry.*) A double roof consisting of two ordinary gable-roofs and a valley between them.

M-teeth. (*Saw.*) Teeth in groups of two, like the letter _M_M_.

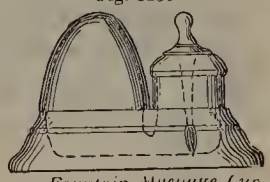
Mu'ci-lage-bot'tle. One for containing mucilage, a solution of gums tragacanth and acacia. In the example (Fig. 3249), an elastic band is applied to the stem of the brush and the cover of a mucilage, marking, or other bottle, for the purpose of always keeping the brush elevated above the contents of the bottle, except when forced down for the purpose of taking up some of the fluid for use.

Fig 3249.



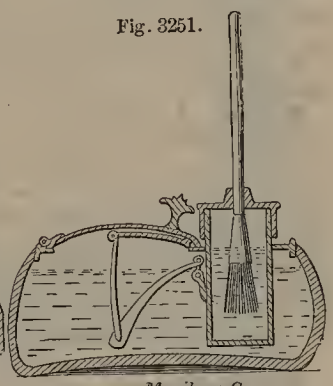
Mucilage-Bottle.

Fig. 3250.



Fountain Mucilage-Cup.

Fig. 3251.



Mucilage-Cup.

Fig. 3250 has a supply fountain.

In Fig. 3251, a water-tank forms a receptacle for the brush. The lid is attached to a rod which swings back with it and forms a wiper for the brush.

Muck-bar. Bar-iron which has passed once through the rolls. It is usually cut into lengths, piled, and rerolled.

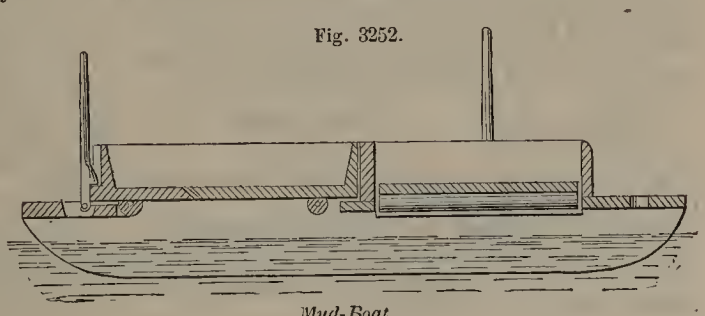
Muck-fork. (*Agriculture.*) A manure-fork.

Muck-rake. (*Agriculture.*) A drag or rake for removing or unloading manure.

Muck-roll. The *roughing* or first roll of a rolling-mill train.

Mud-boat. One for carrying off mud dredged from a river-channel or bar, and having convenient provision for discharge. In the example, the mud-boat has several vats resting on two boats which are placed parallel and connected by timbers. The floors of the vats have sectional drops for discharge, and

Fig. 3252.



Mud-Boat.

lever-catches which control their discharging functions.

Mud-drag. A machine for raking up the mud of a river, in order that it may be carried off by the current. A *hedge-hog*.

Mud-hole. A covered opening in the bottom of a boiler for discharging the dirt and sediment.

Mud-pat'tens. Broad wooden sole-boards for traveling on mud-lands.

Mud-plug. (*Steam-engine.*) A tapered stopper, removed from a boiler to allow the mud to escape.

Mud-sill. The lowest sill of a structure, which may be in the mud or on the surface of the earth.

Mud-valve. (*Steam.*) A valve by which mud is discharged from a steam-boiler.

Mud-wall. One of earth or clay.

One of materials laid in clay as a substitute for mortar.

Muff. 1. (*Glass.*) A roller or cylinder of glass for flattening out into a glass plate.

2. (*Wear.*) A fur pocket for the hands held in front of the person.

"This day I did first wear a muffle, being my wife's last year's muffle, but now I have bought her a new one." — PEPYS's *Diary*, November 30, 1662.

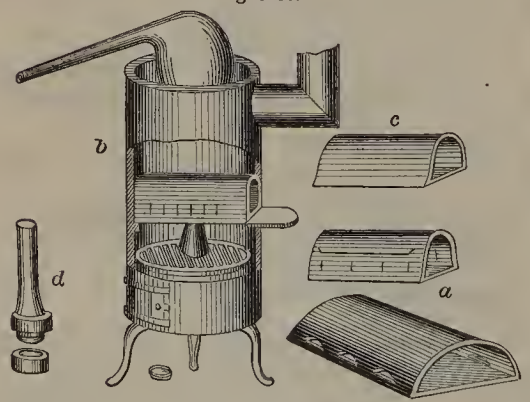
3. A joining tube driven into the ends of two adjoining pipes.

Muf'fle. 1. (*Metallurgy.*) An oven-shaped vessel (*a*) of baked fire-clay, used in assaying for containing the cupels or cups in which the alloy under investigation is fused. It is open at one end and closed at the other, and has slits in the sides to permit a draft of air through it. Its use is to protect the cupels from impurities of fuel while permitting access of air. It forms a chamber in the midst of the incandescent coals of the furnace *b*. See MUFFLE-FURNACE; ASSAYING-CUPEL.

2. A pulley-block containing several sheaves.

Muf'fle-fur'nace. (*Metallurgy.*) A furnace with a chamber which is surrounded by incandescent fuel,

Fig. 3253.



Muffle-Furnace.

and in which cupellation or fusion of metals is performed; the former especially. (See CUPELLATION.) The holes in the sides of the muffle are important, as through them a draft is established which oxidizes the lead and some other associated metals.

a, muffle. *c*, closed muffle.
b, muffle-furnace. *d*, cupel-mold.

In the process of assaying, the *muffle* contains the cupel in which the metal is placed.

Arsenic is sublimed from arsenical pyrites in a muffle whose eduction-channel leads to a condensing chamber where the arsenious acid is deposited. See ARSENIC-FURNACE; CUPELLATION.

Muf'fler. 1. (*Music.*) A soft cushion employed to terminate or soften a note.

2. A knit wrapper for the head or throat.

Mule. A spinning-machine in which the rovings are delivered from a series of sets of drawing rollers to spindles placed on a carriage, which travels away from the rollers while the thread is being twisted, and returns toward the rollers while the thread is being wound.

It was invented by Samuel Crompton, and perfected in 1779, so far as to make it an excellent working machine. Subsequent improvements by Roberts, Mason, and others have brought it to its present state, in which it is automatic, and is known in some parts of England as the "iron man," in allusion to its singularly deft and delicate action.

The combination which gave rise to the term *mule* was the junction of the *drawing-rollers* of Arkwright with the *jenny* of Hargreaves. The hybrid scarcely came within the definition of a *mule*, which is declared by Senator Nesmith of Oregon to be "a being without pride of ancestry or hope of posterity." The object of the machine is to deliver the roving with the required degree of attenuation and twist it as delivered. For this purpose, the spindles, instead of being stationary, are placed on a movable carriage, which is wheeled out to twist the threads and wheeled in again to wind on the spindles.

Mr. Kennedy, the friend and biographer of Crompton, states: —

"The great and important invention of Crompton was his spindle-carriage and the principle of the thread having no strain upon it till it was completed. The carriage with the spindles could, by the movement of the hand and knee, recede just as the rollers delivered out the elongated thread in a soft state, so that it would allow of a considerable stretch before the thread had to encounter the stress of winding on the spindle. This was the corner-stone of the merits of his invention."

Crompton's mule was also termed the *muslin machine*, from its producing yarn finer and softer than was obtained from any other machine then known, more nearly to the standard of the India muslins, which are yet the admiration of the cotton-trade.

Crompton gave up his invention to the public in 1780. Thirty-two years afterward he received £5,000 from government as a compensation for his services. This was unfortunately frittered away in starting his sons in business, and the father was again in poverty. A subscription was raised for him which supported him during the last two years of his life. He died in 1827.

Crompton obtained no patent, and his poverty was not rendered additionally miserable by vexatious litigations and hopes deferred. There seems to have been no conscience among manufacturers as to the right of property in patents during the period marked by the inventions of Hargreaves, Arkwright, and Watt. The latter two, by indomitable energy and the possession of partners of skill, capital, and business tact, survived the attack of the Ishmaelites, and left honored names and good estates. (See SPINNING.) Crompton's first machine contained only 20 or 30 spindles, and was built to supply his own loom with good yarn. The traverse of the mule-carriage was only 5 feet. The distance traveled is now much greater, and the carriage sometimes carries 1,000 spindles.

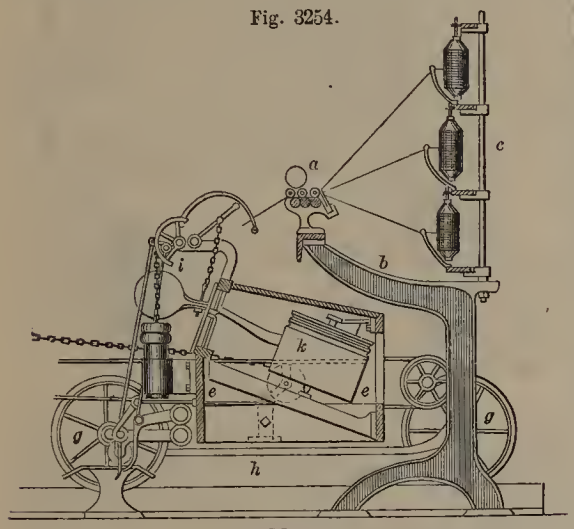
Previous to the invention of the mule few spinners could make yarn of 200 hanks to the pound, the hank being always 840 yards. The natives of India were at the same time making yarns of numbers ranging from 300 to 400. Houldsworth of Manches-

ter, England, has lately succeeded in making No. 700, which was woven in France.

Mr. Roberts invented the self-acting mule in 1825. By this, the carriage, after the thread is spun, is automatically returned to the rollers, requiring no attendance, except for the purpose of joining threads which may be accidentally broken. This is performed by children.

In Fig. 3254, *a* is the triple set of drawing rolls, working in heads fixed on the roller-beam *b*. *c* is the creel for holding the bobbins in three rows. *e e* is the carriage, resting on wheels *g g*, which run on the railway *h*. Spindles *i* are set in a nearly upright po-

Fig. 3254.



Mule.

sition. *k* is one of a series of drum-cylinders with grooves around the upper end for the driving band.

This machine is not self-acting, but illustrates the principle of action.

The drawing and stretching action of the *mule-spinner* makes the yarn finer and of a more uniform tenuity than the mere drawing and twisting action of the *throstle*. As delivered by the rollers, the thread is thicker in some parts than in others; these thicker parts, not being so effectually twisted as the smaller parts, are softer and yield more readily to the stretching power of the mule; by this means the twist becomes more equable throughout the yarn. Throstle-spinning is seldom employed for numbers higher than 40 or 50 hanks to the pound, because smaller yarn would not have strength to bear the drag of the bobbin, but in mule-spinning the yarn is built upon the spindles without subjecting it to appreciable strain.

The mule-carriage carrying the spindles recedes from the rollers with a velocity somewhat greater than the rate of delivery of the reduced roving, the rapid revolution of the spindles giving a twist to the yarn, which stretches it farther. When the rollers cease giving out the rovings, the mule-spinner still continues to recede, its spindles still revolving, and thus the stretching is effected.

The distance to which the spindles recede from the rollers while both are in action is called a *stretch*. This is usually about 54 to 56 inches.

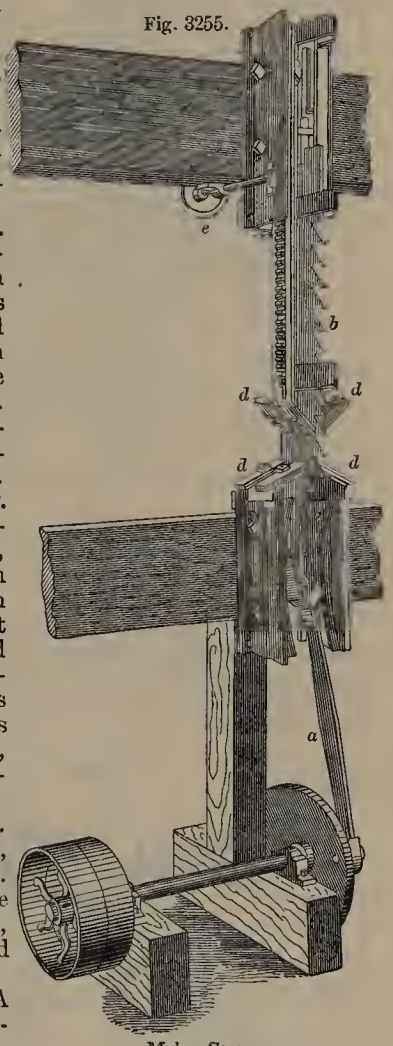
The space over which the carriage moves in excess of the paying out of the rollers is called the *gaining* of the carriage.

The space traversed by the carriage after the paying-out action of the rollers is stopped is called the *second stretch;* during this latter the spindles are revolved very rapidly, to save time.

When the *drawing*, *stretching*, and *twisting* of the yarn are thus accomplished, the mule disengages itself from the parts of the machine by which it has been driven, and the carriage is returned to the rollers, the thread being wound in a *cop* upon the spindle as the carriage returns.

The specific difference between the action of the throstle and the mule is, that the former has a continuous action upon the roving, *drawing*, *twisting*, and *winding* it upon the spindle; while the mule *draws* and *twists* at one operation as the carriage runs out, and then *winds* all the lengths upon the spindles as the carriage runs in.

Fig. 3255.



Muley-Saw.

Mu'let; Mu'lette. A Portuguese vessel with three lateen sails.

Mu'ley-head. The sliding carriage to which the muley-saw is attached, and which moves in guides on the frame of the mill. The saw is attached to a *muley-head* at each end.

Mu'ley-saw. A mill-saw (German, *mühlsäge*, mill-saw) which is not strained in a *gate* or *sash*, but has a more rapid reciprocating motion, and has guide-carriages above and below, called *muley-heads*.

Mull. (Fr. *molle*.) A thin, soft, cotton goods. Varieties are known as Swiss, India, starched mull, etc.

Mul'lar. A stamp with an intaglio ornament, for giving a salient impression to metal upon which it is struck.

Mul'ler. A grinding apparatus consisting of a stone or slab with a flat surface, which is moved upon a stone table or slab to grind and mix pigments, etc. The action is sometimes called porphyrization.

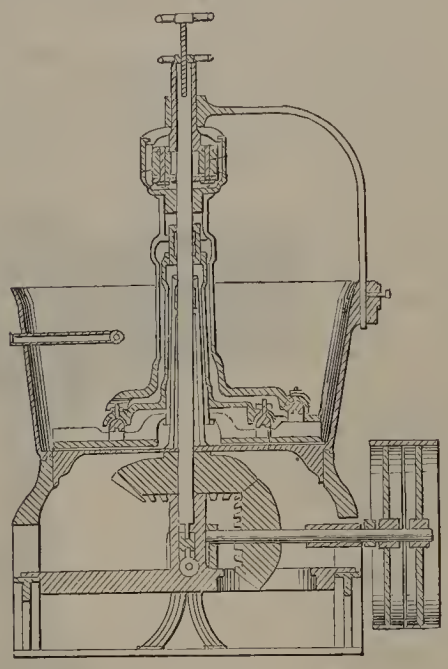
A painter's stone and muller, much like the modern, were disinterred from an Egyptian tomb, and are now in the Abbott collection.

The mulling action is shown in the mill (Fig. 3256). This is a form of amalgamating pan in which the mullers are attached to two sets of arms, and rotate in the pan in different directions by means of gear-wheels and an axial shaft, which passes down through the bottom of the pan, and is put in motion by gearing. See list of allied devices under MORTAR; MILL; ORE-MILL.

Mul'lion. 1. A vertical bar separating the compartments of a window, especially used in the Gothic

and double-casement windows. The horizontal bars are *transoms*. *Munnion, monyeale, monial.*

Fig. 3256.



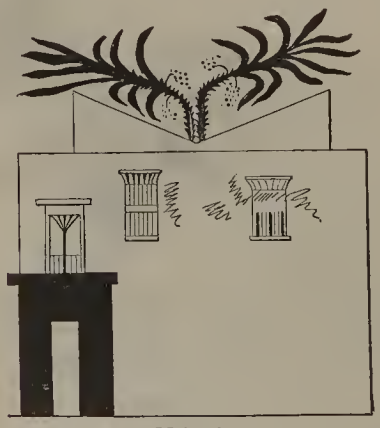
Muller.

2. A style or upright division in wainscoting.

Mull-mus'lin. (*Fabric.*) A thin, soft, transparent muslin. Finest quality.

Mul'quf. Perhaps the most ancient device for ventilating, specially constructed for that purpose, is the *mulquf*, which has been in use in Egypt for at least 3,000 years, and is still to be seen attached to the modern houses of Cairo and other towns. The name

Fig. 3257.



Mulquf.

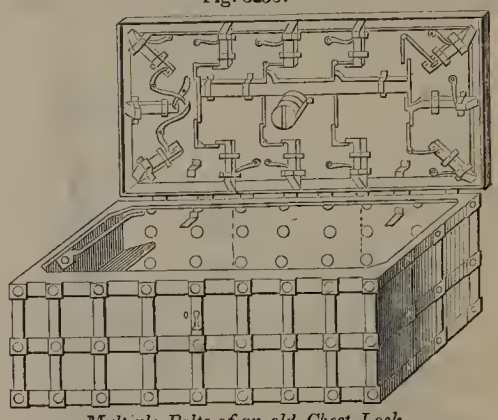
is Arabic, and means *wind-conductor*. It is open in the direction of the prevailing wind, which is conducted down the descending chute and thence disseminated through the house. The illustration is from an ancient drawing in a tomb at Thebes. Wilkinson states that it consists of a strong wooden framework to which planks are nailed, according to the length and breadth desired. If cheaper materials be required, the framework is covered with reeds or mats, plastered. The illustration shows two, presented respectively, it may be assumed, up and down the river. They are common features in Cairene architecture, where their presentation is usually N. W., being toward the prevailing wind.

Mul'ti-flue-boil'er. A steam-boiler having a large number of moderate-sized or small flues, as that of a locomotive.

Mul'ti-ple Bolt. An arrangement by which a number of bolts are simultaneously moved. It was a common feature on the strong-boxes of other days, and has been revived upon safe-doors.

The engraving represents an old French lock, with four corner bolts, six others on the sides, and two

Fig. 3258.

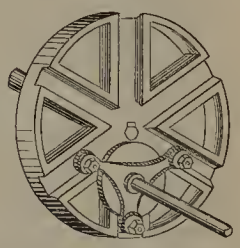


Multiple Bolts of an old Chest-Lock.

on the ends. Each bolt has a spring, and is acted upon by a lever, operated by the central and subsidiary bolts. The keyhole in front of the box is merely a deception, the real keyhole being in the middle of the lid, concealed by a secret door opened by a spring.

Mul'ti-ple Wheel. The rollers on the arms of the smaller wheel traverse in the diametric grooves on the face of the larger wheel, and impart motion to the latter.

Fig. 3259.



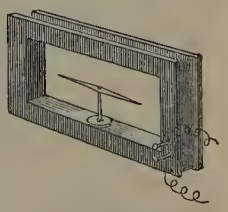
Multiple Gearing.

One revolution of the smaller wheel gives half a revolution to the larger. If the *larger* wheel be the *driver*, two revolutions of the smaller wheel are obtained for one of the driver.

It is substantially the same as the *slosh-wheel*, which has two diametric grooves and two slides. The relation of speed is the same in each. See SLOSH-WHEEL; TRAMMEL.

Mul'ti-pli-er. 1. (*Telegraphy.*) A frame with a number of repetitive windings of the same wire, in order to obtain their cumulative effect in deflecting a magnetized needle, when the wire is traversed by a current. An invention of Schweiger.

Fig. 3260.



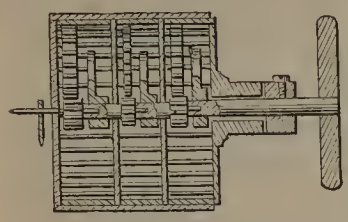
Multiplier.

Unless the current is sensibly diminished by the resistance of the wire, each convolution exerts an equal force on the needle, thus multiplying the deflective force as many times as there are turns in the wire. Owing to the resistance, however, it frequently occurs in practice that a few turns of stout wire exert a greater influence on the needle than numerous convolutions of much finer wire.

2. An arithmometer for performing calculations in multiplication. See ARITHMOMETER.

Mul'ti-ply-ing-gear'ing. An arrangement of cog-wheels by which motion is imparted from wheels of relatively larger diameter to those of smaller, so as to increase the rate of rotation. This is used in many kinds of machinery. The example shows a nest of gearing for increasing the rate of motion from the driving-shaft of a harvester to the rate required by the cutter-bar. The motive shaft has arms which carry spur-wheels engaging the inner gear of the drum, and a pinion which is fast to the second shaft, having similar arms and spur-wheels engaging a pinion on the third shaft. This may be extended as far as desired; the proportion between the planet-wheels and their pinions regulates the increase of speed gained.

Fig 3261.



Multiplying-Gearing.

Multiplying-gearing is also used with some forms of propeller-engines.

Mul'ti-ply-ing-glass. One with a number of facets repeating the object. A toy.

Mul'ti-ply-ing-lens. A plano-convex lens whose curved surface is divided up into a number of plane facets which give separate images.

The facets of a multiplying-lens or a cut diamond resemble those of the compound eye of some insects. Each little facet of the cornea gathers a certain set of pencils of light, and the main necessity for the motion of the eyeball is avoided. The facets in the compound eyes of the insects following are cited as,

The butterfly	17,335
The dragon-fly	12,544
The house-fly	7,000

The eye of a flea has been so mounted with the assistance of a microscope as to exhibit a flame or other object as a grand miniature illumination or assemblage.

Mul'ti-ply-ing-ma-chine'. One form of calculating-machine. See Fig. 328, ARITHMOMETER. See also CALCULATING-MACHINE.

Mul'ti-ply-ing-wheel. One which increases the number of movements in machinery. See MULTIPLYING-GEARING.

Mul'ti-tu'bu-lar Boil'er. One having numerous tubes in which water circulates.

Mun'go. (*Fabric.*) A woolen cloth made of second-hand material. Old cloth and woolen goods are torn to pieces by cylindrical machines, and, being mixed with various proportions of pure wool, are re-spun and woven. Druggets and low-priced goods of but little strength are the result. *Shoddy.*

Mun'nion. 1. (*Ship.*) A piece which divides the lights in a window of a stern or quarter gallery.

2. A bar separating the compartments of a Gothic or casement window. A *mullion.*

Mun'tin. (*Carpentry.*) A vertical piece between the panels of a double-panel door. The name is probably derived from *munnion*, and that from *mullion*, a pier between the divisions of a Gothic window. Mullion is from *molding* (Fr. *moulure*), signifying the form.

Muntz's Met'al. An alloy for plates for sheathing the bottom of ships. Patented in England in 1832. It resembles several previously patented alloys, all of which were designed to be rolled while red-hot, and to be used for the purpose stated.

See the following; also table on page 61.

	Kier, 1779.	Collins, 1800.	Muntz, 1832.
Copper . . .	54	55.5	50, 60, 63
Zinc	40	44.4	50, 40, 37
Iron	5.4		

Mu'ral Cir'cle. An astronomical instrument consisting of a graduated circle, furnished with a telescope and firmly affixed to a wall, in the plane of the meridian. It is used for determining with great accuracy altitudes and zenith distances, from which may be found declinations and polar distances, and has a graduated circle secured at right angles to its horizontal axis. See TRANSIT.

The old Hindoo instrument for obtaining by observation the sun's altitude and zenith distance is described in the Sanscrit treatise "Sûrya Siddhânta." It was a wheel suspended by a string, graduated to degrees, having its lowest point and the extremities of its horizontal diameter distinctly marked, and with a projecting peg at the center. When used, its edge is turned toward the sun, so that the shadow of the peg falls upon the graduated periphery, and the distances of the point where it meets the latter from the horizontal and lowest points of the wheel respectively are the required altitude and zenith distance of the sun.

Among celebrated instruments may be mentioned the mural circle made by Graham, for Halley, at Greenwich, and those made by Ramsden in 1788, for Piazzi, at Palermo, and one for Dublin. See GRADUATING-INSTRUMENTS.

The *mural circle* is so called because it is supported by means of a long axis passing into a wall.

The mural circle of the National Observatory in Washington was made by Mr. William Simms of London. It is 5 feet in diameter, made of brass, and cast in a single piece. It is divided into spaces of 5′ each, upon a band of gold inlaid on the rim and perpendicular to the plane of the circle. Placed at equal distances round the circle are six micrometer microscopes, with an acute cross of wires at their foci for reading angles less than 5′. Five revolutions of the micrometer are designed to measure 5′ upon the circle. The micrometer heads being divided into 60 equal parts, each division represents 1″ of arc. The object-glass of the telescope has a clear aperture of 4 inches and a focal length of 5 feet. At its focus is a fixed diaphragm containing seven vertical wires and one horizontal wire. There is also another diaphragm, movable by a micrometer screw, and furnished with five horizontal and equidistant wires, by which the distance of any star from the fixed horizontal wire is measured as it passes through the field. The magnifying power usually employed is 125. The cost of the mural circle was $3,550.

The mural circle is placed in the meridian, and is used for determining the polar or zenith distances of celestial objects.

Mural quadrants and *mural sectors* are instruments of lesser arcs, similarly mounted.

Mu'ral Quad'rant. Differs from the preceding in the merely quadrantal character of the graduated arc.

The mural quadrant of Tycho Brahe at Uraniborg had a radius of five cubits. The collection of astronomical instruments at this observatory was by far the finest that had ever existed.

Mu-rom'e-ter. An instrument for measuring small spaces. — WEALE.

The term may refer to a mural attachment, as in the case of the mural circle, for measuring arcs of the meridian. The instrument is permanently attached to a perpendicular wall.

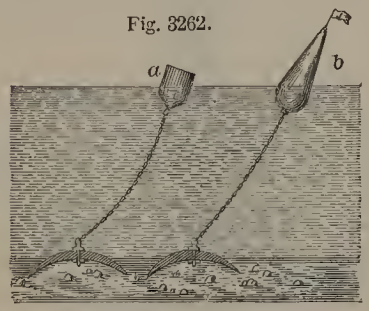
Mu-sette'. (*Music.*) A name by which the bagpipes are known among some of the European conti-

nental nations. Named from a mountebank performer.

Mush'room-an'chor. An anchor with a central shank and a head like a mushroom, so that it can grasp the soil however it may happen to fall. Invented by Hemman of Chatham, England, 1809. See ANCHOR.

That used by the United States Lighthouse Board for anchoring buoys is shaped like an inverted saucer, having a shackle and

Fig. 3262.



Mushroom-Anchor.

chain attached to the center of its convex side. The chain is just long enough to give the buoy sufficient prominence above the surface and allow for the rise and fall of tides.

It imbeds itself in the ground, offering a strong resistance to an upward pull and not a little to a lateral one.

a, *can*-buoy with anchor.

b, *nun*-buoy with anchor.

Mu'si-cal Box. (*Music.*) A small musical instrument having a toothed barrel operating vibrating tongues.

Mu'si-cal Clock. One which plays tunes at the hours. It may consist of a musical-box attachment set in motion by the clock-work at the expiration of the hours.

One of late construction is cited as having a large bell on which the hours are struck, a chime of eight bells for the quarters, and a four-bell chime for "Cambridge quarters." It will also play seventy different tunes upon sixteen bells, the tune being selected by turning a hand on a dial; and by means of pushing a small stud the same tune may be repeated any number of times. There are ten barrels, each adapted for seven tunes, and readily substituted one for another. Other musical clocks are also provided with mechanical movements, dancing figures, soldiers marching past to the tunes played on the bells, all automatic. See also CLOCK, pp. 568–71.

Mu'si-cal Com'pass. (*Music.*) The range of notes of the voice or of a musical instrument.

Ptolemy first described the diatonic scale now in use. It appears that the ancients had no notation for time, and no music in parts; even their melodies were formed on different principles from the modern. Pope Gregory the Great (A. D. 590) denoted the scale by seven Roman letters, which represented in different octaves replicates of the same sound. Previous to this the sounds in the double octave had been denoted by fifteen letters. The letters of Gregory were placed over the syllables to which they were to be sung. Afterward, a little higher or lower than a median line, as an assistance in reading the notes. At a later period, on seven lines, in imitation of the strings of a lyre. Guido of Arezzo, a Tuscan monk (about 1022), reduced the number of lines to five, and placed the points of notes on lines and spaces. He also introduced *solmization*, or singing by syllables, as in the *do, re, mi, fa*, yet used, though not exactly so called. Bars were first used in the beginning of the seventeenth century.

The original compass of the piano-forte was 5 oc-

Fig. 3263.

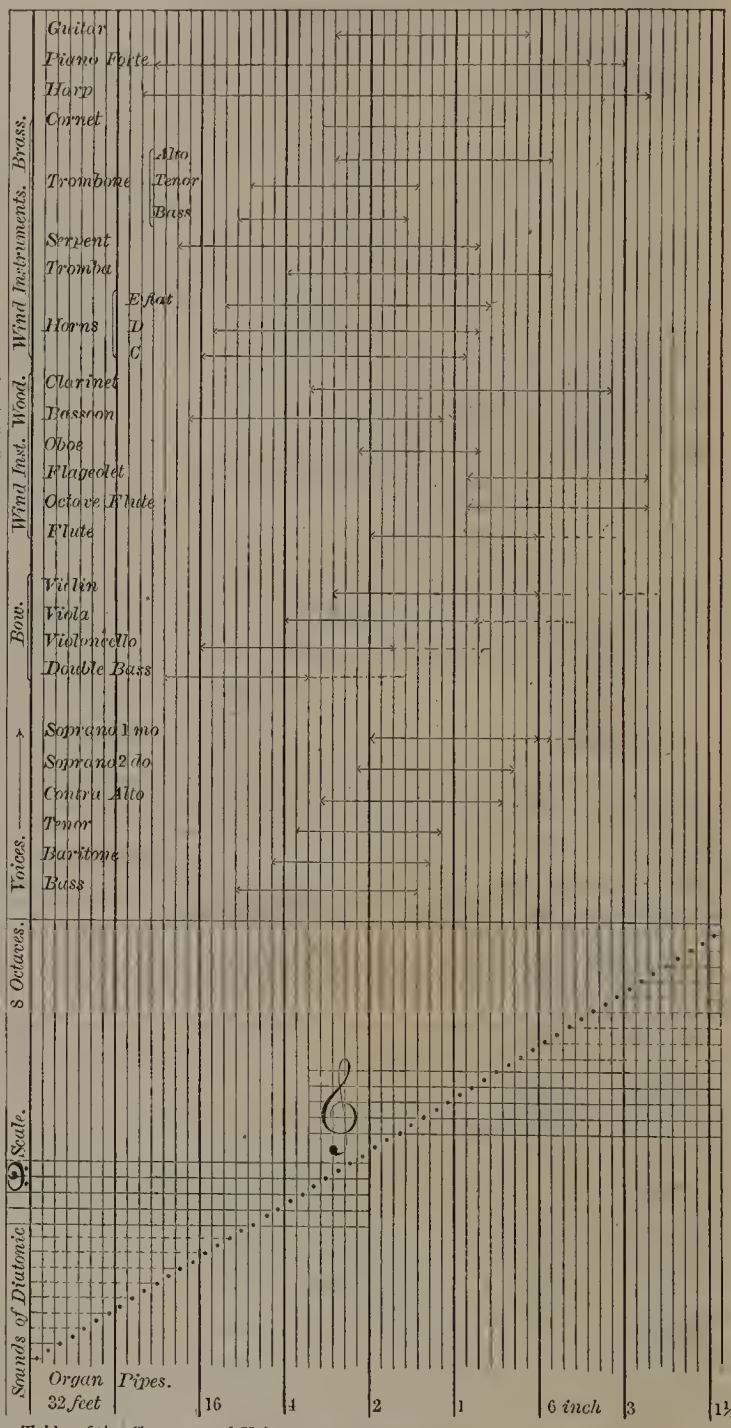


Table of the Compass of Voices and Instruments, showing the Place each occupies in the Scale.

taves. This was gradually extended to 6½ and 7 octaves, the latter being the usual range on grand-pianos. See PIANO-FORTE.

Piano-fortes were exhibited in London, 1851, with 7½ and 8 octaves.

Mu'si-cal Glass'es. (*Music.*) A musical instrument consisting of a number of goblets, tuned by filling them more or less with water, and played by touching their rims with the dampened finger. The size of the glasses being equal, the smaller quantity of water produces the lower note in the scale.

The instrument was revived and improved by Benjamin Franklin in 1760. See HARMONIUM.

Mu'si-cal In'stru-ments. Devices designed to create a succession of harmonious sounds are to be found at the earliest historic periods, including under that term the times when men wrote by pictures, long before phonetic signs and syllables were invented.

We find them among those races which stand low down in the scale of humanity, and ancient monuments show that at a very distant period they had advanced to a considerable degree of perfection.

> "The birds instructed man,
> And taught him songs before his art began.
> And while soft evening gales blew o'er the plains,
> And shook the sounding reeds, they taught the swains;
> And thus the pipe was framed, and tuneful reed."
> LUCRETIUS, *De Rerum Naturæ*, B. V.

The musical instruments of a rude people are themselves rude. Those of the Feejees are the conch-shell, nose-flute, pipes, a jew's-harp made of a strip of bamboo, and drums.

The Maories have three or four varieties of flutes, a lyre with three or four strings, and conch-shells.

The Society-Islanders have wooden drums with shark-skin heads; shell trumpets having holes in the small ends into which are fitted bamboo canes about three feet long; bamboo flutes blown through the nose.

A greater variety and improved construction indicates a more advanced civilization.

In the sculptures and paintings of Karnak are representations of musical instruments carried in processions. They consist of harps, maces, sistrums, lutes, flutes, and drums.

We suppose musical science and art to have originated in Egypt, — the land where, over all others, the husbandman could tell when he sowed his grain how much he was to reap in harvest; where the chances were reduced to the minimum; and where, first of all lands, a cultivated leisure was possible.

The musical instruments of Egypt utterly disprove the statements of Diodorus Siculus, that music was unknown in that country. A remarkable instance, which may stand as a complete refutation, is found in the harps discovered by Bruce depicted upon a tomb near the ruins of Thebes. These were so superior to the harps of 100 years since, that doubts were entertained of the fidelity of the representation; but Rosellini's "Monumenti dell' Egitto," and Wilkinson's "Ancient Egyptians," have removed all doubts. (See HARP.) The testimony of Herodotus, Plato, and others also enforces the statement, that music arose in Egypt and came thence to Greece.

When the Israelites left Egypt, they carried away with them some of the arts with which they had become acquainted in their at first voluntary and subsequently enforced stay.

According to Father Kircher, thirty-six kinds of instruments played by striking were employed by the Jews in the service of the Temple. Others reduce the number to twenty-two. Among these, the class termed *neghinoth* included stringed instruments of a long oval or rounded shape with perforated bottoms; the strings, three in number, were struck by a horse-hair bow. These were called *trichordon* in Greek, and *trifidium* in Latin.

Other instruments of the kind were the *psalter*, *nablium*, or *cithara*, denominated by the Hebrews *assur*, *nevel*, *kinnor*, *maghul*, *minnim*.

Of these no intelligible description remains. Some have supposed that the *psalter* was not in fact an instrument, but that the term was applied merely to harmony produced by the voice in conjunction with instruments. According to Josephus, however, it was an instrument with twelve strings played on by the fingers. The general opinion is that it was a species of harp.

The Hebrew drum, termed *thoph*, appears to have been covered at one end only. It was struck with a rod of wood or iron, and is said to have been of Egyptian origin. (See DRUM.) The *gnesto berusim*, according to Rabbi Hannase, was a species of wooden mortar struck on the interior with a rounded stick.

The *maghul* is believed to have been a stringed instrument, but was, perhaps, a circle surrounded by little bells. A tambourine.

The *minghinim* has been confounded with the psalter and the cymbal, but Kircher states that it was a quadrangular plank, having a handle, to which small globes of wood and copper were attached by chains and cords, producing a clear jingling sound which could be heard at a considerable distance. Perhaps a kind of sistrum.

The *magraphe temid* was used to call the people to the Temple. Kircher supposes it to have been similar to a bell, but as no description remains this is a mere matter of inference.

The *mafra kitha*, according to Kircher, was composed of a series of reeds of different sizes inserted into a hollow piece of wood. It had holes opened and stopped by the fingers similarly to the flute.

The Hebrews employed at an early period the horns of animals as musical instruments, and also made flutes from the leg bones of birds, as the crane and stork.

According to Josephus, no less than 40,000 instruments were collected by Solomon for the service of the sanctuary, divided into different classes appropriate for each class of the services.

With regard to the form and use of many instruments employed by the ancients, no authentic account remains. In many instances conjecture has been substituted for fact.

They were generally used at festivals and religious ceremonies, are frequently mentioned by Ovid and other poets, and some are shown on ancient marbles.

Athenæus states that in the triumphal procession of Ptolemy Philadelphus there were 600 musicians in the chorus, 400 of whom played on the cithara or lyre.

Then, as now, musical instruments were ranged in three great classes, — wind, string, and percussion. In Numbers, chap. xix, the Hebrews are directed to sound trumpets on going into battle, and the walls of Jericho fell at the sound of the trumpet. This has been the warlike instrument of all nations from the earliest ages, except the Spartans, who employed pipes and soft instruments to temper rather than inflame their martial ardor.

Trumpets with two tubes were sometimes used by the ancients. At a later period the tube was recurved, as in the modern trumpet, of which the bugle is a variation. The trumpet used in Persia and the East is a very long tapering tube with flar-

ing mouth. A similar instrument without a flaring mouth is used in Turkey and India.

The Chinese have trumpets of wood.

The Florida Indians, according to the history of Jacques Le Moyne, made a species of trumpet by winding the bark of trees spirally, forming a tube wider at one end than the other, to which oval plates of gold, silver, or other metal were attached by strings, intended apparently to jingle in accord with the instrument.

The Greeks ascribed the invention of the three-stringed lyre to Thoth, the Egyptian Mercury; and Terpander, the Greek, is credited with founding the Greek music, and with the invention of the seven-stringed lyre. He also contrived a method of representing musical sounds, writing music. Pythagoras added an eighth, completing the octave. The Greeks excelled in the use of the flute, using a variety of instruments of different pitch, but probably played in unison, not in harmony. It is apparently well settled that they did understand counterpoint.

The Romans seem to have added nothing to the art.

Toward the end of the fourth century, St. Ambrose composed a musical service for the church of Milan. Previous to this time, the Christian service was probably various in different parts of the Empire: in some it doubtless was Oriental and noisy; in lands where the Grecian civilization prevailed, it was copied from the dramatists, and consisted of airs, recitatives, and responses; in other regions again it probably followed the chants as performed at the pagan altars, and among the Christianized Jews it doubtless long followed the Hebrew models.

Two tubes, one sliding within the other, a form from which the trombone is derived, appear to have been early employed. See Plate V., Bonanni's "Istromenti Armonici," Roma, MDCCLXXVI.

From being at first straight, the tube was made curved, slightly, perhaps, at first, afterwards so as form a semicircle or more, and then so as to make one or more convolutions like the modern French horn.

Tyrrhenus, son of Hercules, it is said, first employed a sea-shell, perforated at the smaller end, as an instrument of music. The tritons attendant on Neptune are represented as blowing sea-shells.

The flute was originally sounded by a mouth-piece at the end, like the clarinet. In this form it is of great antiquity. The German flute is a comparatively modern invention. See FLUTE.

The ancient flute was frequently made double, the tubes diverging outwardly from the mouth. From an instrument of this kind to the compound or pandean pipes the transition is easy, and we accordingly find the latter in vogue at a very early period. The Chinese *tam-kim*, which is played by opening and closing the ends of a series of pipes filled by a single mouth-piece, is an analogous device. See Plate XLIII., Bonanni, *supra*.

The bagpipe is said to have come from Lydia, and is mentioned by Suetonius in his life of Nero. See BAGPIPE.

The organ is of great antiquity, but the word "organ" is applied in the Bible, according to St. Augustine, to a variety of instruments. The invention of the hydraulic organ is attributed to the Alexandrian Greeks. (See ORGAN.) The pneumatic organ, even in its most primitive form, does not appear to have been used prior to the seventh century.

The *cithara*, or an equivalent instrument, is the most ancient of the stringed class known, being mentioned in the fourth chapter of Genesis; Jubal having been the progenitor of such as handle the *harp* (or cithara) and *organ*. The connection between instruments of this kind, as the lyre, harp, and others on the same principle, is so close that we can hardly decide positively which is the primitive form. The monuments of Egypt illustrate a number of varieties. See HARP; LYRE; LUTE.

The *violin*, *guitar*, *mandolin*, and similar instruments are of later origin. The first were struck by a *plectrum*, or a small rod, or by the fingers. See GUITAR.

The *monochord* and *tromba marina*, or marine trumpet, are played with a bow. (See Plate LXIV., Bonanni.) The latter has merely a flat sounding-board, on which the single string is stretched.

The so-called German lyre is a *hurdy-gurdy*.

The Kaffirs have a species of *monochord*, consisting of a string stretched on a bow and twanged with an ornamented swan-quill, and a sort of violin formed by stretching a string over a kind of drum with a handle. This is played with a bow.

Instruments played by percussion seem to have been among the first known. Miriam is represented as playing on the *timbrel* after the passage of the Israelites across the Red Sea. (Exodus, chap. xv.) This appears to have been similar to the tambourine, and was also probably surrounded by little bells. See TAMBOURINE.

The *tam-tam*, formed by stretching a skin over the opening of a hollow hemisphere, cylinder, quadrangular box, or even a gourd, and beaten with a stick, has been found among all races and tribes of people. See DRUM.

The *maramba*, formed by thus preparing a number of gourds of different sizes so as to accord with one another, is in use alike among the inhabitants of Africa and Southern America. Bamboos similarly attuned and arranged are also employed by some African tribes.

Drums, *tam-tams*, and *gongs* are much in vogue among the Chinese and other imperfectly civilized or barbarous nations, with whom noise and music are synonymous terms. With nations having more appreciation of harmony, such instruments have been more sparingly employed, for the purpose of marking time or of reinforcing the sound of a combination of other instruments at proper intervals.

The *sistrum* and *crotalus*, or rattle, jingling devices caused to sound by shaking, were used in former times with this view; but at the present day, with the exception, perhaps, of the cymbals and triangle, instruments of the jingling and clashing kind are banished from the orchestra. See CASTANET; CYMBAL; TRIANGLE; GONG; BONES.

The arrangement of bells in a diatonic series, so as to play tunes, is of comparatively modern origin. See PAVILLON CHINOIS; CARILLON.

For a list of the more generally known instruments, see specific index, next page.

The following list and classification of musical instruments is given in Berlioz's "Treatise upon Modern Instrumentation and Orchestration":—

STRINGED INSTRUMENTS.	Vibration effected by the bow	Violin. Viola. Viole d'amour. Violoncello. Double-bass.
	Played by the hand .	Harp. Cithern. Guitar. Banjo. Mandolin.
	With keys . . .	Piano-forte.

Wind Instruments.	With reeds	Hautboy. Corno iuglesi. Bassoon. Basson de quinte. Double-bassoon. Clarinet. Corno di bassetto. Bass-clarinet. Saxophone.
	Without reeds	Flute. Octave-flute.
	With keys	Organ. Melodeon. Accordeon. Concertina.
	Brass instruments with mouth-piece	Horn. French-horn. Trumpet. Cornet. Bugle. Tromboue. Ophicleide. Bombardon. Bass-tuba.
	Voices	Men, women, children, and artificial soprani.
Percussion Instruments.	Of definite sonorousness	Kettle-drum. Cymbals (ancient). Sets of bells. Glockenspiel. Dulcimer. Keyed harmonica. Bells.
	Variable sonorousness, and producing characteristic sounds	Drum. Long drum. Tambourine. Cymbal Triangle. Gong. Pavillon chiuois.

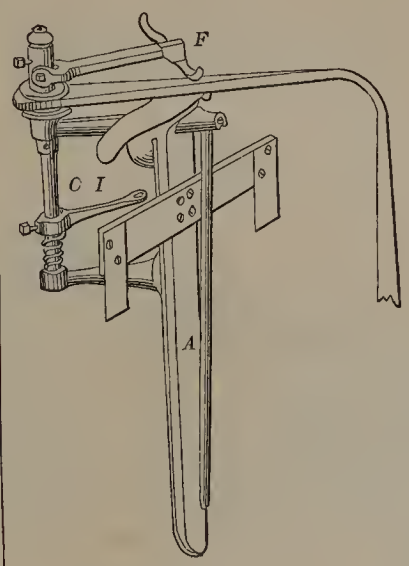
See under the following heads: —

Accordeon.
Æolian attachment.
Æolian harp.
Æolina.
Æolophon.
Angelot.
Apollonicon.
Atabel.
Autuphon.
Bagpipes.
Balalaika.
Bandore.
Banjo.
Baritone.
Barrel-organ.
Basset-horn.
Bassette.
Bass-horn.
Bassoon.
Bass-viol.
Bell.
Bird-call.
Bird organ.
Bombard.
Bones.
Bow-instrument.
Bugle.
Cabinet-organ.
Call.
Calliope.
Carillon.
Castanets.
Chanter.
Chime.
Chronometer.
Cithara.
Claribella.
Clarichord.
Clarion.
Clarinet.
Claveein.
Clavichord.
Clavicitherium.
Clavicymbal.
Claviole.
Concertina.
Contra-bass.
Cornet.
Cornet-a-piston.
Cornopean.
Coupler.
Cremona.
Cromorna.
Crotalo.
Crowle.
Crwth.
Cymbal.
Decachordon.
Double-bass.
Double-drum.
Drone.
Drum.
Dulcimer.
Echometer.
Eölian.
Fagotto.
Fiddle.
Fife.
Flageolet.
Flute.
Flute-organ.
French-horn.
Gendcr.
Gong.
Guitar.
Guitar-banjo.
Hand-organ.
Harmonica.
Harmoniphou.
Harmonium.
Harmouometer.
Harp.
Harpsichord.
Hautboy.
Hexachord.
Horn.
Horn-pipe.
Hunting-horn.
Hurdy-gurdy.
Hydraulicon.
Jew's-harp.
Kalidophone.
Kallifthorgan.
Kemengeh.
Kent-bugle.
Key.
Key-bugle.
Kin.
Knee-swell.
Krum-horn.
Kussier.
Lapideon.
Lute.
Lyre.
Mandoliue.
Mandore.
Manichord.
Manual.
Maramba.
Melodeon.
Metronome.
Monochord.
Mouth-organ.
Musette.
Musical box.
Musical glasses.
Naker.
Oboe.
Octachord.
Octave-flute.
Ophicleide.
Orpheon.
Organ.
Organ-harmonicon.
Orlo.
Pandean-pipes.
Pandore.
Pedal.
Percussion-stop.
Piano-forte.
Piccolo.
Pipe.
Pipe-organ.
Pitch-pipe.
Polychord.
Psaltery.
Reboe.
Recorder.
Reed.
Reed-orgau.
Sackbut.
Sax-horn.
Saxophoue.
Seraphine.
Serpent.
Side-drum.
Sistrum.
Snare-drum.
Spiuet.
Sticcato.
Stop.
Syrinx.
Tabor.
Tabret.
Tambourine.
Tam-tam.
Theorbo.
Timbrel.
Tom-tom.
Triaugle.
Trombone.
Trumpet.
Tuuing-fork.
Tympano.
Viola.
Viole d'amour.
Violin.
Violoncello.
Violone.
Virginal.
Wood-harmonicon.
Zithern.

Mu'sic-box. (*Music.*) An automatic playing instrument in which a row of vibrating tongues are tripped by pins on a barrel rotated by a spring. Boxes are made on a small scale for two tunes, and of many other sizes, some very large, expensive, and having a capacity for playing many tunes. The rapidity of the successive notes is such that it is impossible to make one tongue make the requisite number of notes in succession without striking upon the following pin; therefore, there are two, three, or four teeth of the comb having the same tone or pitch, and placed contiguous, which allows the rapid recurrence of the same note by placing the pins side by side, following, instead of behind each other. The regulator, or *fly*, is adjustable; the wings which impinge against the air are capable of limited extension and contraction, thus retarding or accelerating the rate of revolution of the cylinder.

The tones of the tongues are regulated by their length and thickness; the shorter they are, the quicker the vibrations, and the higher in the scale is the pitch. To the long teeth, which are to vibrate slowly for the low notes of the scale, are attached masses of lead of sufficient weight to give the requisite tone. The tuning of these teeth is accomplished by altering their thickness by stoning, filing, or scraping, till the proper pitch is obtained. To prevent too long vibration of any of these teeth, a system of dampers is employed; on the under side of the longer tongues small pieces of steel spring are attached; to the middle teeth of the comb small bits of goose-quill are attached by cement, the short teeth, having a short vibration, requiring no dampers.

Fig. 3264.



Music-Leaf Turner.

Fig. 3265.

Music-Pen.

Mu'sic-clamp. A temporary binder or file for holding sheet music in convenient form for use and preservation. See PAPER-CLAMP.

Mu'sic-leaf Turn'er. The arm *A* is

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held to the music-stand by a clamping piece ; the fingers are inserted between the pages and turned by the ratchet-plate *F*, which slides freely over the fingers when turned in one direction, but engages them one by one when it is moved in the opposite direction. It is fixed on the spindle *C*, which is partially rotated by the arm *I* connected by a cord with a treadle, and is restored to its former position by a spring.

Mu'sic-pa'per. Paper ruled with lines for writing music.

Mu'sic-pen. A pen made for ruling at once the five lines which, with the intervening spaces, form the staff of music. The instrument has a brass head and five parallel pens like ruling pens ; that is, they consist of bent strips of brass which form spouts to conduct the ink from the reservoir to the paper.

Mu'sic-print'ing. Music was first printed by types on which the ledger lines were cast. The font displayed all possible variations of character and position. In 1720, music was engraved on plates.

Breitkopf's type, 1764, had the ledger lines on separate type. Reinhard printed the ledger lines from engraved plates, and the notes from type at a second pull.

Another and more modern plan is to put up the ledger lines in rules and cast the type so as to admit of the ledger line crossing them when necessary.

Music has been for a long time engraved by cutters and punches on soft metal plates and printed by the copperplate press.

The compositor, having the manuscript of the music before him, selects a thin sheet of soft metal of the proper size, and sinks, by the use of a machine constructed for the purpose, the staff-lines into the metal. He then proceeds to sink in the notes, rests, points, bars, slurs, etc., by the use of suitable punches, each musical character or element of a character having its appropriate punch.

The plates thus prepared have thus produced upon them the piece of music in sunken characters, which characters are next filled up nearly to the level of the plate with beeswax. The musical notation now appears as if printed in wax upon the plates, the surfaces of which are highly polished.

To print from these plates the ink is first distributed uniformly over the entire surface by a hand-roller. The surfaces are then wiped off with a cloth, which removes all the ink from the polished parts, while it still adheres to the wax in the punched depressions.

The pressman lays the paper upon the surface of the plates, and then passes them through the ordinary copperplate D-press. While the above is the usual plan adopted for preparing plates for the best music, a very large proportion of the music of the present day admits of being set up for the usual letterpress printing. The *sorts* of the case embrace all the various possible requirements of the music.

Mu'sic Re-cord'ing-in'stru-ment. A machine to record the notes played upon a keyed instrument.

The organ or piano is connected with the recording apparatus by a magnetic telegraph. Beneath each note of the three manuals and of the pedals, and connected with each stop of the organ, is a small brass spring, which is pressed down whenever the piece to which it is attached is brought into action. From each spring wires run to a galvanic battery, and to the recording apparatus, which may be situated at any convenient distance from the organ. When the spring is pressed down, connection between the battery and the recording apparatus is formed, and the electric current passes through. The recording apparatus is similar to that used in Morse's telegraph. Attached to clock-work, by which a uniform motion is produced, are two cylinders, between which is carried a strip of paper divided into about 250 longitudinal divisions, — one for each note and stop in the organ. Corresponding to each of these divisions is a magnet, whose armature carries a lever armed with a style, which indents the paper as long as the electric current is passing through. When any note or stop is brought into action, the spring connected with it is pressed down, the circuit is completed, the corresponding armature is attracted to its magnet, and the division of the paper belonging to the note struck is indented with a line proportionate in length to the time during which the note is held down. A staccato touch will be represented by a simple dot, while a longer tone will be recorded by a more prolonged indentation. The clock-work is so geared that the paper is carried forward on the rollers at the rate of about one half an inch per second, thus recording each note in the most rapid playing, at the rate of about ten notes per second by a line one twentieth of an inch in length, and longer notes by lines proportionally extended.

Mu'sic-stool. A stool with a pillar leg, and a revolving seat adjustable as to hight by means of its screw-stem.

Mu'sic-type. Movable types for setting up music to be printed by the ordinary printing-press.

The first plan was that of Cowper, who printed by two operations ; the first printing the lines and the second the notes.

The second plan was that of Branston, who punched the notes and cut the lines deeply in a plate and from this obtained a stereotype, from which he printed in the usual manner.

The present plan of detached types was introduced by Hughes of London, about 1840. See pp. 310, 311, of Ringwalt's "Encyclopedia of Printing."

Mu'sic-wire. *a.* A steel wire employed for instruments of wire.

b. Wire drawn of various patterns and used in some kinds of music-printing.

Mu'sic-writ'er. Several contrivances were suggested or made during the last century for "writing extempore voluntaries or other pieces of music, as far as any master shall be able to play them upon the organ, harpsichord," etc. (*Phil. Tran.*, 1747.) Creed invented a machine for this purpose in England in 1747 ; Hennersdorf of Berlin, one in the following year. John Freke in England, Unger and Hohlfield in Prussia, worked at the idea. Unger formed a part of the harpsichord. The device of Hohlfield was attachable to any instrument. Descriptions were transmitted to the Academy of Berlin in 1752, and published in Brunswick in 1774.

Mus'ket. (*Fire-arms.*) The fire-arm of the infantry soldier. It superseded the arquebus, on which it was an improvement. Formerly, smooth-bore and muzzle-loading, modern progress has improved it into the rifled breech-loader of the present. See FIRE-ARMS.

Mus'ket-oon. A short musket used by cavalry and artillery previous to the introduction of breech-loaders.

Mus'lin. (*Fabric.*) A bleached or unbleached thin white cotton cloth, unprinted and undyed ; finer than calico. Varieties are known as Swiss, buke, mull, jaconet, lawn, saccharilla, harness, leno, nainsook, seerhand, foundation, cambric, cord, check, figured, long-cloth, tamboured, muslinet, organdie.

Muslins are so called from Moussol in India. First imported into England in 1670. Made in England, 1778 – 80. Other very different styles of fabric are now indifferently called muslins, and the term is

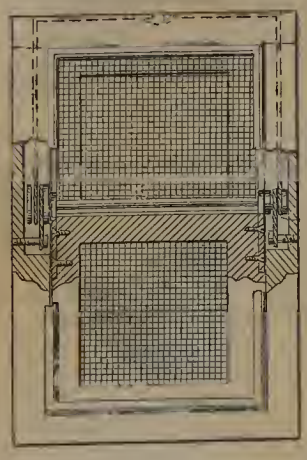
used differently on the respective sides of the Atlantic.

At the London Exhibition in 1862, a few yards of English muslin were shown, woven from a thread .00216 of an inch in diameter, but the finest Dacca thread is only one quarter the size; and there is this essential difference, that the finest European muslins have little or no durability, whereas the Dacca muslins, of far finer quality, are strong and lasting. This is in part explained by the fact that the thread of the India fabric, being made by hand, is more closely twisted and compressed, — the number of twists to an inch in the best English being 68.8; the Indian, 110.1.

One pound of the finest Dacca thread is 250 miles in length. The most delicate pieces are transported in bamboo reeds, and a tube eighteen inches long and one inch in diameter will hold twenty-two square yards. One of the best pieces which found its way to England was ten yards long by one yard wide, weighed only three ounces two pennyweights, and could be passed through a very small ring. A Persian ambassador to India, on his return to his native country, once presented the king with a cocoa-nut-shell containing a turban sash sixty cubits long. The warp threads, in the best qualities, number from 1,000 to 1,800 in a piece one yard wide. Four square yards of some specimens weigh only 566 grains. The Emperor Aurungzebe reproved his daughter because, on a certain court occasion, the outline of her form could be distinctly seen through her dress. Her defense was that her covering consisted of seven garments.

To the fine and delicate Indian muslins the names of "webs of woven air," "dew of night," "running waters," etc., are given by the natives. They use the spinning-wheel generally for the ordinary fabrics, but the spindle still holds its place in the hands of the Hindoo woman when employed in spinning thread for the finer muslins. For these the Hindoo woman first cards her cotton with the jawbone of the *boalee* fish; she then separates the seeds by means of a small iron roller worked backwards and forwards upon a flat board. An equally small bow is used for bringing it to the state of a downy fleece, which is made up into small rolls to be held in the hand during the process of spinning. The apparatus required for this consists of a delicate iron spindle having a small ball of clay attached to it in order to give it sufficient weight in turning, and imbedded in a little clay there is a piece of hard shell, on which the spindle turns with the least degree of friction.

Fig. 3266.



Musquito-Bar.

Attention is paid to the temperature of the air during the process of spinning, and the spinners in the dry climate of the northwest of India work under ground to secure a moist and uniform atmosphere.

The Hindoo's loom has a yarn-beam, a cloth-beam, heddle, swinging lathe, shuttle with an eye, treddles, and temple.

Mus'lin-de-laine. (*Fabric.*) A cotton chain and woolen filling, or an all-wool ladies' dress-goods, printed like calicoes.

Mus'li-net. (*Fabric.*) A kind of muslin of which there are several varieties, as single-cord, fancy satin-stripes, and figured.

Mus-qui'to-bar. A net to ward off musquitoes, gnats, and other flying insects. It is usually a canopy which surrounds the bed, but is sometimes applied to the windows and doors to exclude outdoor insects from a room.

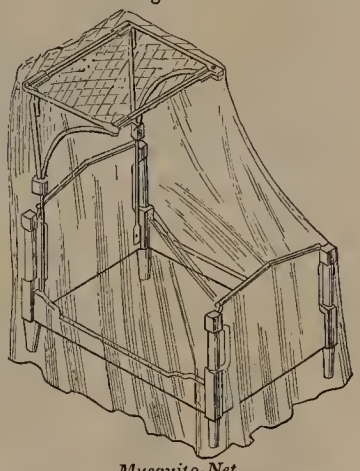
In the example, it is applied to a window. The cords are attached to screws fixed to the casing, and are passed once around the pulleys, so that the act of raising or lowering the sash revolves the roller and rolls up or unrolls the bar or netting.

Mus-qui'to-can'o-py. A netting acting as a protection against musquitoes.

The *conopeum*, or musquito-bar, is mentioned by Horace. It was of linen thread, of a gauze texture. Its name is literally rendered, *gnat-curtain*, and survives in our word *canopy*.

It is usually supported upon a tester or canopy, and depends all around the bedstead. In Fig. 3267 it is upheld by a frame laterally expansible, and its parts detachable so as to be attached to any bedstead, or packed in a trunk.

Fig. 3267.



Musquito-Net.

In Fig. 3268 the cot-bed is supported on springs, and the musquito-netting supported by attachment to a wall and a foot-rest.

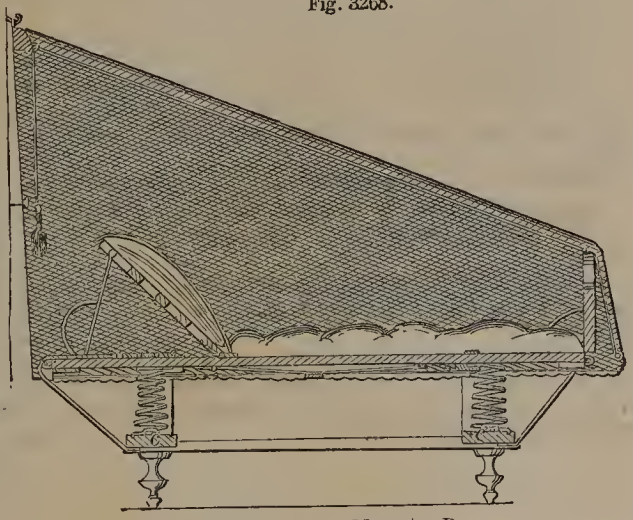
Fig. 3269 has a calash-top.

Mus'role. (*Menage.*) The noseband of a bridle.

Mute. A device to deaden the sound of a musical instrument, wind or stringed.

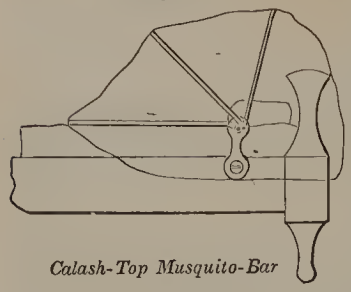
a. Fig. 3270 is an example of one applied to the pavilion of a horn. A plug is made to fit the bell of the instrument, and has a central tube, which allows only a part of the sound to issue. By this means the sound is

Fig. 3268.



Hospital Cot and Musquito-Bar.

Fig. 3269.



Calash-Top Musquito-Bar

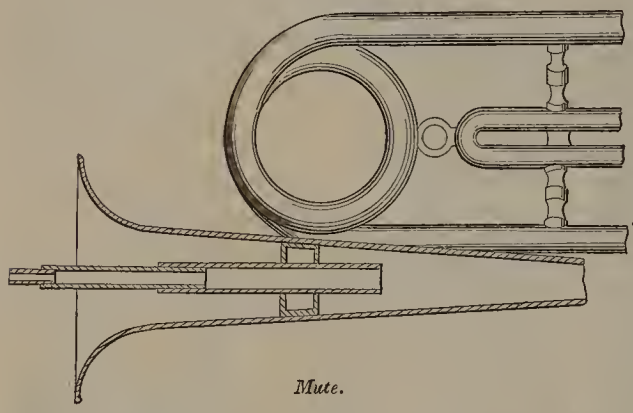
deadened, without throwing the instrument out of tune, and pupils are enabled to practice on the instrument without annoying their neighbors.

The mute is also used to produce echo effects.

b. A little implement placed on the bridge of a stringed instrument to deaden its sonorousness, and give it a mournful sound. A *sordine.*

Mu'ti-la-ted Wheel. A wheel, from a part of the perimeter of which the cogs are removed. It is

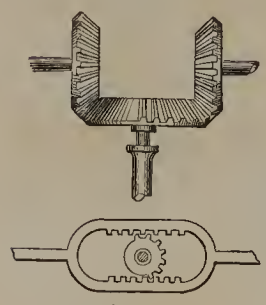
Fig. 3270.



Mute.

usually adapted to rotate constantly in one direction, and impart an intermittent motion to other cog-wheels or a reciprocating motion to a rack-bar, by alternate connections to one or the other of said wheels, or the respective racks of the bar.

Fig. 3271.



Mutilated Gear.

Mu'tule. (*Architecture.*) A projecting block worked under the corona of the Doric cornice, in the same situation as the modillions in the Corinthian and Composite orders; it is often made to slope downward toward the most prominent part, and has usually a number of small guttæ or drops worked on the under side.

Muz'zle. 1. (*Guns and Ordnance.*) The mouth of a gun, closed by the *tompion*, and, in ships, secured by *muzzle-lashings* to the upper part of a port.

The *muzzle-ring*, around the mouth of a cannon, has been suppressed in many modern styles of ordnance.

2. A gag or mask placed over the head of a dog or the muzzle of a calf or vicious horse. It may be made of heavy leather, galvanized wire, or block-tin covered with leather.

One of the heaviest descriptions of muzzles was used upon the untamed "Cruiser" before he was made tractable by Mr. Rarey. The illustration shows the muzzle and halter; the former was of iron and leather, a bar passing in front of the lips which compelled him to lick up his food.

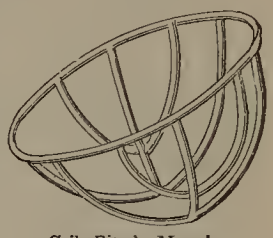
Fig. 3272.

"Cruiser" Muzzled.

Fig. 3273 is a muzzle to prevent biting the manger, but allow the horse to pick hay.

3. The piece at the forward end of the plow-beam by which the draft is attached. The *clevis.* Also called the *bridle*, or the *plow-head.*

Fig. 3273.



Crib-Biter's Muzzle.

Muz'zle-cap. (*Ordnance.*) The cover over the muzzle of a gun.

Muz'zle-sight. The *front-sight*, screwed into the swell of the muzzle of a gun or the muzzle-band of a howitzer. It is made of iron or steel, and is equal in hight to the *dispart* or difference between the semi-diameters of the base-ring and muzzle.

Muz'zle-stop'per. (*Ordnance.*) A *tompion*, to close the mouth of a gun.

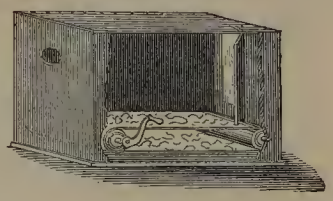
Muz'zle-strap. (*Menage.*) A broad strap, which is buckled around the horse's mouth to prevent his biting; used in place of a muzzle.

My'o-dyn'a-mom'e-ter. An instrument for measuring the strength of the muscles.

Myr'i-o-ra'ma. An exhibitional picture made of a number of separate sections which are capable of being associated in various ways so as to form distinct scenes.

Myr'i-o-scope'. This is a variation of the kaleidoscope, and, like the latter, depends upon the multiplication of images, which coalesce in such manner as to form a geometrical pattern.

Fig. 3274.



Myrioscope.

A square box has a sight-hole in front, and at the rear are two plane mirrors which are arranged at a suitable angle. On horizontal rollers is a piece of embroidered silk or other ornate fabric, which is caused to traverse by means of a crank-handle on one of the rollers. This causes a pretty display when the ornamental figures are multiplied and thrown into geometrical apposition.

The top of the box is of oiled muslin or other translucent material which admits sufficient light.

N.

Nab. 1. (*Fire-arm.*) The cock of a gun-lock. 2. (*Locksmithing.*) The keeper of a door-lock.

Nac'a-rat. (*Fabric.*) Fine linen or crape dyed of a pale red color.

Nail. 1. A sharp narrow piece of metal for attaching objects by driving it into or through them. It differs from a *spike* or a *tack* in being smaller than one and larger than the other; from a *screw* in that the latter is not driven but twisted into the wood; from a brad in having a head, while the *brad* has but a spur.

The *nail* used by Jael, the wife of Heber the Kenite, when she smote Sisera, was a tent-pin (*wated*). The hammer was the mallet used to drive in the tent-pin. The nail was probably of hard wood, and when "fastened in a sure place" was useful then as now. It is not all ground that will hold a tent-pin securely when a wind-storm comes on. Deborah's song is a magnificent pæan, but we must agree with Kitto that Jael's was "a treacherous and cruel act."

The nails of ancient Egypt were usually of bronze. Iron nails have mostly perished with rust.

The tools of the Tahitians, when first discovered, were made of stone, bone, shell, or wood. They had no idea of metal. When they first obtained nails, they mistook them for the young shoots of some very hard wood, and, hoping that life might not be quite extinct, planted a number of them carefully in their gardens. Eight years after the first voyage of Captain Cook, that distinguished navigator says iron had quite superseded stone and bone.

Until eighty years since nails were always forged. Before the introduction of machine-made nails, 60,000 persons were employed in forging nails in Birmingham, England.

One authority states that there are about 300 varieties of nails made in England, and 10 sizes of each variety. We have no such to present.

The English mode of numbering, 7 lb., 8 lb., etc., denotes that 1,000 of the respective varieties would have those weights.

This mode of enumeration is substantially similar to our own, but much variation has occurred.

The following are the names, lengths, and number to the pound of the several sizes of nails: —

Name.	Inches long.	No. to the pound.
2*d.* fine	1	880
3*d.* fine	1¼	665
3*d.* common	1¼	400
4*d.*	1½	280
5*d.*	1¾	195
6*d.* common	2	155
6*d.* fencing	2	80
7*d.* common	2¼	120
7*d.* fencing	2¼	65
8*d.* common	2½	90
8*d.* fencing	2½	50
9*d.* common	2¾	70
9*d.* fencing	2¾	40
10*d.* common	3	55
10*d.* fencing	3	30
12*d.*	3½	45
16*d.*	3½	28
20*d.*	4	20
30*d.*	4½	16

Nails are cast for some purposes, but their quality is inferior. They may be improved by ANNEALING (which see).

Garden nails for driving into brick walls, and nails for shoe-soles, are cast.

In 1718 an English patent was granted to Clement Dawbeny for cutting iron into nail-rods; it was worked by water-power.

Clifford, 1790 (England), patented a process of making nails by swaging between rollers whose depressions agreed with the shape of the nail; half in each roller. The heads and tails joined so as to make them in a string, to be afterward separated by nippers. It was proposed to treat a sheet in this way, converting it into strings of nails.

Clifford's next machine was to cut the nails from a bar rolled thicker at the head-end. The nails were made at another operation, in a swage.

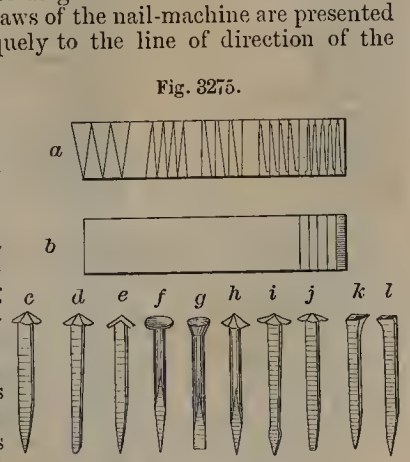
Thirty or forty patents in England followed these of Clifford's, but the American nail-cutter was the first to cut the nails and swage the heads at one operation. See NAIL-MAKING MACHINE.

The preliminary operations of smelting, puddling, squeezing, rolling, cutting, fagoting, re-heating, and re-rolling in the nail-plate train are described under their appropriate heads. The plate thus prepared is taken to the cutting-machine, which shears off pieces as long as the width of the plate, the strips having a width to suit the particular size of nail for which they are intended. This is a little longer than the destined nail, as a part of the slip cut from it is to be upset to form the head. The nail-strips are heated by being placed on their edges on red-hot coals, whence they are taken one by one by the pinchers of the boy who tends the nail-machine.

It will be understood that the plate as it comes from the nail-plate train has fibers running in the direction of its length. This is cut transversely into strips in which the fibers run across. A transverse cut on this strip gives a nail in which the fibers are lengthwise. See diagram *b*.

The cutting jaws of the nail-machine are presented somewhat obliquely to the line of direction of the nail-plate, so as to remove a taper piece, the wide end being swaged into a head and the sharper end remaining as a point, and the nail-plate being turned over after each cut.

Fig. 3275.



Nail-Plate and Nails.

Sparables, sprigs, brads without heads, and glazier's points are all of them of a triangular shape, and are merely cut from the strip. Brads with heads and headed nails are made by cutters of peculiar form, which leave projections upon the head-ends of each nail, as seen in the figure, which illustrates the various kinds mentioned.

Nails are assorted as to —

1. *Purpose;* as, *hurdle, pail, deck, scupper, sheathing, fencing, slating.*

2. *Form of the heads;* as, *rose, clasp, diamond, billed, clout, countersink, dog,* etc.

3. *Form of points;* as, *flat, sharp, spear, clinch.*

4. *Thickness;* as, *fine, bastard, strong.*

5. *Size;* from 1½ lb. to 40 lbs. That is, 1,000 nails of a given size will weigh so many pounds.

6. *Material;* as, *copper* nail, for sheathing of ships, metal covering of roofs. *Galvanized*, plated with zinc, etc.

7. *Mode of manufacture;* as, *wrought, cut, cast.*

The accompanying cut shows some of the peculiarities as to *heads, points,* and thickness.

c. Rose-nail; sharp point, a flat head showing facets, square shank.
d. Rose-nail; flat point, square shank.
e. Clasp-nail; bastard (medium) thickness, barbed head, square shank.
f. Clout-nail; fine point, flat circular head, and round shank.
g. Counterclout nail; countersunk head, flat point, round shank.
h. Dog-nail; faceted head, round shank, fine point.
i. Kent-hurdle nail; a broad, thin, rose head, flat shank, spear-point for clinching.
j. Rose-clinch nail; rose head, square point, either clinched or riveted down on a washer or *rove*.
k. Horseshoe-nail; countersunk head, square shank, fine point.
l. Brad; billed head, square shank, fine point.
To which may be added *spikes, tacks,* and other varieties.

Nichol's nail (1873) is a strong, light nail formed of sheet-metal with or without a head, and stiffened by longitudinal grooves, ridges, or corrugations.

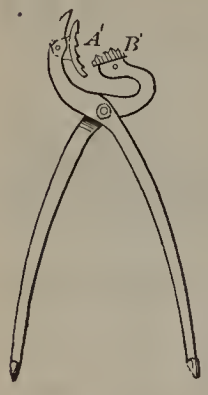
See under the following heads: —

Bastard-nail.
Brad.
Brob.
Bullen-nail.
Clamp-nail.
Clasp-nail.
Clinch-nail.
Clout-nail
Counterclast-nail.
Countersink-nail.
Cut-nail.
Deck-nail.
Diamond-nail.
Dog.
Door-nail.
Doubling-nail.
Fencing-nail.
Fine nail.
Flat-head nail.
Flat nail.
Forge.
Frost-nail.
Garden-nail.
Gate-nail.
Gimp-nail.
Glazier's point.
Hob-nail.
Horseshoe-nail.
Hurdle-nail.
Lead-nail.
Mop-nail.
Nail-clincher.
Nailer's forge.
Nail-hammer.
Nail-machine.
Nail-plate feeder.
Pail-nail.
Picture-nail.
Plenshing-nail.
Ribbiug-nail.
Rose-nail.
Screw.
Screw-nail.
Scupper-nail.
Sharp nail.
Sheathing-nail.
Sparable.
Spear-nail.
Spike.
Spike-extractor.
Spike-machine.
Sprig.
Tack.
Tack-claw.
Tack-driver.
Tack-hammer.
Tack-puller.
Tin-tack.
Tree-nail.
Trunk-nail.
Weight-nail.
Wheelwright's nail.
Wire-nail.

2. (*Blasting.*) A taper copper rod used in tamping to make a hole by which the fuse or train may reach the charge.

3. A stamping instrument.

Fig. 3276.



Nail-Clincher.

Fig. 3277.

Nail-Driver.

4. A measurer of length, 2¼ inches = $\frac{1}{16}$ of a yard.

Nail-ball. (*Ordnance.*) An iron ball with a tail-pin projecting from it, to keep it from turning in the bore of the piece.

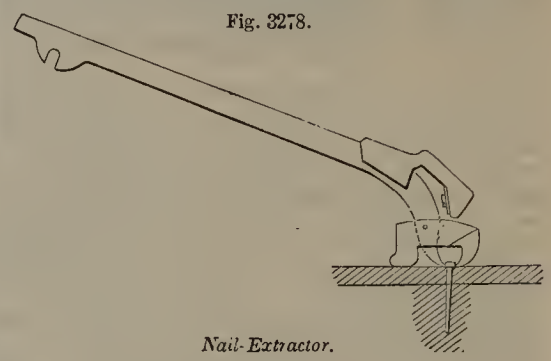
Nail-brush. A small brush for cleaning the finger-nails.

Nail-clinch'er. A blacksmith's tool for clinching the point end of a nail, —or what remains of it—against the hoof. In the example, the steel faces of the clincher are adjustable, being hinged to the jaws so as to conform to the various forms of hoofs, one face *B'* resting below the shoe and the other *A'* clinching the nail.

Nail-driv'er. In Fig. 3277, the point of the instrument is placed at the spot where the nail is to be driven, the plunger is raised, and a nail dropped through the feed-tube; the plunger being then allowed to fall drives the nail home.

Nail-ex-tract'or. An implement with nipping claws for grasping a nail and withdrawing it. In

Fig. 3278.

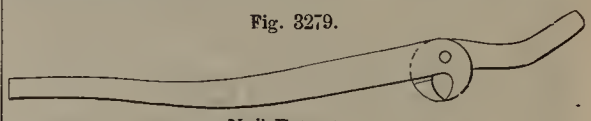


Nail-Extractor.

the example, one claw is upon the fulcrum-piece to which the other jaw is hinged.

In Fig. 3279 the lever and fulcrum are pivoted

Fig. 3279.



Nail-Extractor.

together, and their jaws are clamped together by the act of lifting.

Nail-file. A small, flat, single-cut file for trimming the finger-nails. It is a part of the furniture of the dressing-case, or is cut on the blades of the nail-scissors, or on one small blade of a pocket-knife.

Nail-ham'mer. One for driving nails.

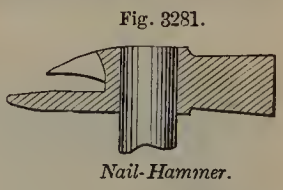
Notably, one which holds a nail for driving, as in the example.

Between the *peen* and the claws is a recess in which a nail may be held to start it in the lumber;

Fig. 3280.

Nail-Hammer.

Fig. 3281.



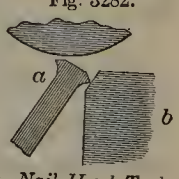
Nail-Hammer.

the other parts are effective for their specific duties.

In Fig. 3280 the nail is gently held by the spring under the poll of the hammer till it is stuck into place ready for driving by a one-armed carpenter.

Nail-head Tool. (*Iron-turning.*) A lathe-tool *a* having a circular expansion with a sharp edge, causing it to resemble, in a degree, a nail-head. One edge is supported on the rest *b*, and the other is applied to the work to be turned.

Fig. 3282.



Nail-Head Tool.

Nail'ing-ma-chine'. 1. (*Carpentry.*) A machine in which, the parts of a box being placed in the

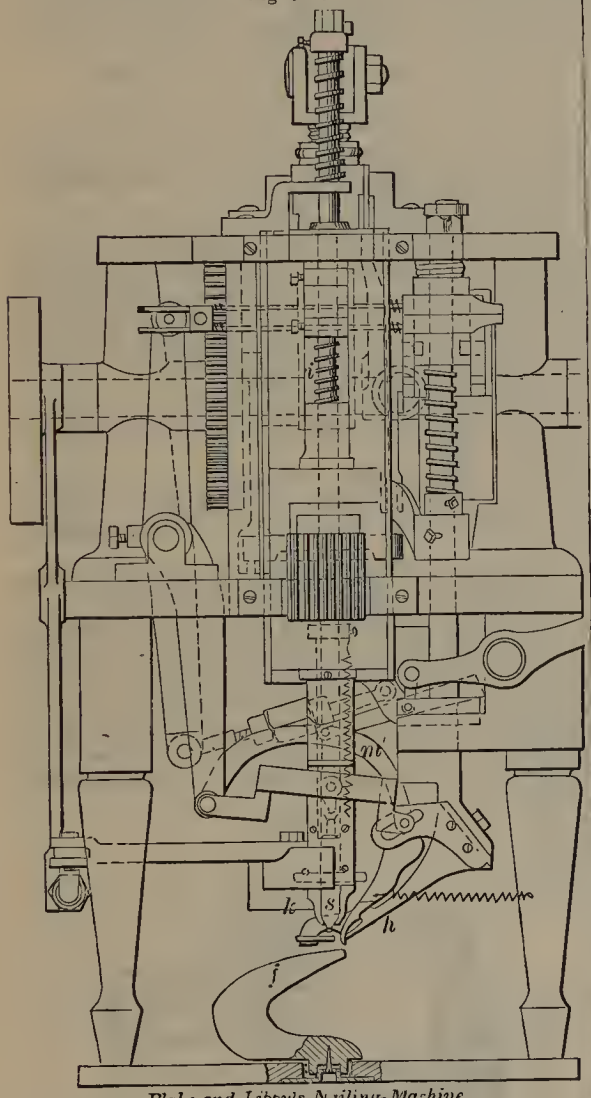
proper relation, plungers advance and drive the nails which secure the sides of the box together, and the sides to the bottom.

Similar machines (see Rice's and Holmes's patents) are used for driving the legs of a wash-board against the sharpened edges of the corrugated zinc plate, sinking the zinc into the legs; an immediately succeeding motion forces the nails which secure the legs to the other portions. The nails are fed into grooves from hoppers, and the drivers advance along the grooves and complete the operation.

2. (*Shoemaking.*) A machine which acts automatically to drive the nails into shoe-soles. The nails are fed from a hopper, or are cut, one at a time as needed, from a coil of wire, and driven into the sole.

In Fig. 3283, the work is held for nailing between the presser-foot *h* and horn *f*. At the lower part of

Fig. 3283



Blake and Libby's Nailing-Machine.

the nail-tube *i* is suspended a pivoted guide *s*, which is vibrated so as to be in line with the tube for receiving a nail and to form an angle therewith when the nail is driven. The nail-tube is turned half round at the moment of driving, so that each nail is driven into the work inclined oppositely to the preceding one. The tube *i* and nail-driver are reciprocated by an eccentric on the driving-shaft, the other motions being derived from cams on the same shaft. The presser-foot arm is adjustable on the arc *m'* to regulate the feed of the work, and devices connected with the presser-foot are provided, by which the motion of the driver-bar is adjusted to varying thickness of the work.

The mechanism by which the nails are cut from the continuous coil of wire is adjustable, so that each nail may be allowed to project entirely through the inner sole and have its end clinched on the horn, or may only penetrate sufficiently to unite the work. The nailing mechanism and presser-foot may each be lifted away from the horn by means of a lever, when it is desired to remove the work.

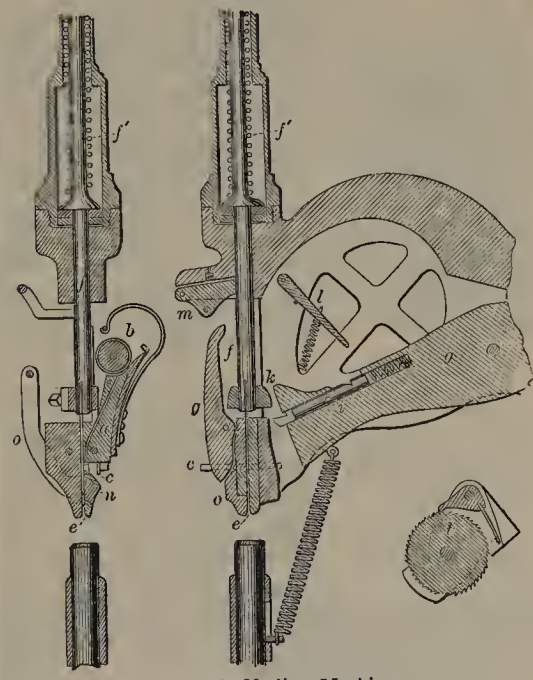
In Goddu's machine (Fig. 3284), for nailing shoe-soles with wire, the wire from a reel is fed downward through a tubular opening in the guide *a* by a feed-wheel *b* advanced by means of a ratchet and pawl. It is severed by a cutter *c* on the upright lever and a stationary cutter, and driven by a nail-driver *e* fixed in the lower part of the vertical shaft *f*.

The lever *g* is operated by depressing a treadle acting against the force of a spring which tends to keep that end in elevated position.

Its upward movement causes the spring-catch *i* to bear against the foot *k* of the nail-driver carrier *f*, and lift it until the arm *l* engages a notch in the spring-catch, retracting the catch and allowing the nail-driver carrier to be acted on by its spring *f'*. A pivoted clamp or binder *m* bears against the carrier, preventing its descent until an arm on the binder is struck by the lever *g* at the end of its upward movement, so that no feed will take place unless the lever is sufficiently raised, the feed-wheel ratchet and pawl being operated by the downward motion of the carrier *f*.

The wire from the feed-guide being severed by the fixed and stationary knives *c' n*, the nail cut off passes into a passage in the transferrer *o*; this is pivoted, and is moved by a stud entering a cam-groove on the lever *g*, so as to present the nail in vertical position at the proper moment to be acted on by the driver.

Fig. 3284.



Goddu's Nailing-Machine.

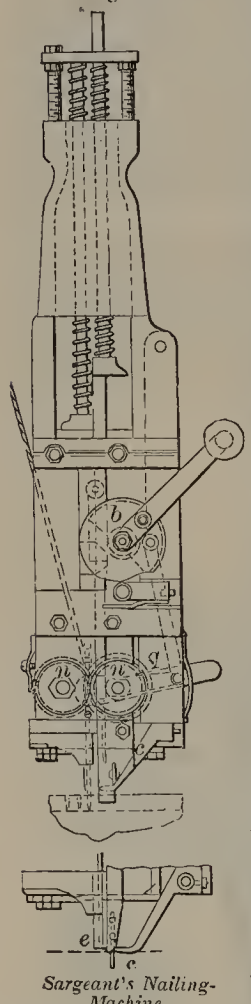
See also patent of Tyson, March 24, 1874, for screwing the uppers upon the soles and heels of boots.

The jack or work-supporting mechanism is mounted on a shaft in the tubular standard *p*, connected by a spring with the lever *g*, so as to be drawn up to the nose-piece *q* when a nail is to be driven.

In Caralli's machine two wires from separate reels are simultaneously fed through two tubes, by which they are conducted to a plate having dies through which they are passed, being at the same time rotated by bevel-gearing, by which screw-threads are cut upon them. As they are screwed into the work, held by mechanism on an arm projecting from the machine, they are severed by movable jaws acting against stationary cutters and operated by a foot-lever, by which the end next to be inserted is cut with a tapering point to facilitate its penetration.

In Prosser's machine, wire from a coil is drawn between a pair of serrated rollers which indent it and also press it into a hole previously punctured by an awl. It is then severed by a pair of shears. The rollers are intermittingly advanced by a ratchet and pawl actuated by a cam on a vertically reciprocating rod, which also operates a lever that depresses the awl and opens and closes the shears. One arm of the shears carries a pawl engaging a ratchet-wheel which turns a wheel by which the work is advanced beneath the nailing mechanism.

Fig. 3285.



Sargeant's Nailing-Machine.

In Fig. 3285, the cam-wheel *b*, through the medium of a rod and pivoted lever *q*, lifts the feed-foot *c*, which, being released, is swung forward by a spring, advancing the work the due interval between two nails. The cam-wheel *b* also raises the awl-driver, the shaft of which has a cam that lifts the driving-bar *e*, and also operates a pawl intermittingly turning a ratchet by which the two geared wire feed-wheels *n n* are rotated. The awl and peg-driver carriers are consecutively released at the proper moments and forced downward by springs on their respective shafts.

The wire drawn from a coil is severed into proper lengths by a cutter operated from the swing-bar *q* by means of a ratchet-wheel and pawl, with an adjusting device for varying the number of teeth advanced at one stroke of the pawl so as to cut different lengths of wire.

Nail-mak'ing Machine'. Nails were formerly forged from the bar, which was reduced by hand to the proper size. In 1606, Sir Davis Bulmer obtained letters-patent for a machine for cutting nail-rods by water-power. The details of his invention are unknown, no records of English patents prior to 1617 existing.

In 1618, Clement Dawbeny patented an improvement on Bulmer's machine, its object being to remedy "the waste that comonly grewe and happened of the iron which was usually cutt into the said small rodd by reason of the often heating, vnapt instruments, and devises then vsed and practised for the cutting thereof." No farther description is given.

Neither of these appear to have been brought into practical use, and were probably soon forgotten.

Machinery for splitting rods for nail-making was first introduced in Sweden. The mode of construction and operation was ascertained by a man named Foley, of Stourbridge, England, who traveled to Sweden and fiddled his way into the affections of the workmen at the mills, where he took mental notes of the machinery and brought them to England, where he established a factory.

In July, 1790, Thomas Clifford patented in England a machine for making nails from the prepared rod by drawing it between rollers having cavities corresponding to the shape of the nail; and in December of the same year he patented a process for drawing bars or plates to a varying thickness and cutting the nails therefrom by a punch. Machines of this kind were in operation at French's factory, Wineburne, Staffordshire, England, in 1792.

Cut-nails were first made in this country.

About 1775, Jeremiah Wilkinson of Cumberland, R. I., cut tacks from plates of sheet-metal, and afterward made nails and spikes in a similar manner, forming the heads in a vise.

Ezekiel Reed of Bridgewater, Mass., in 1786, invented a machine for cutting nails from the plate, and in 1798 obtained a patent for cutting and heading them at one operation. Benjamin Cochran had also constructed a machine of this kind; and Josiah Person of New York, in 1794, patented a machine for cutting nails from the sheet.

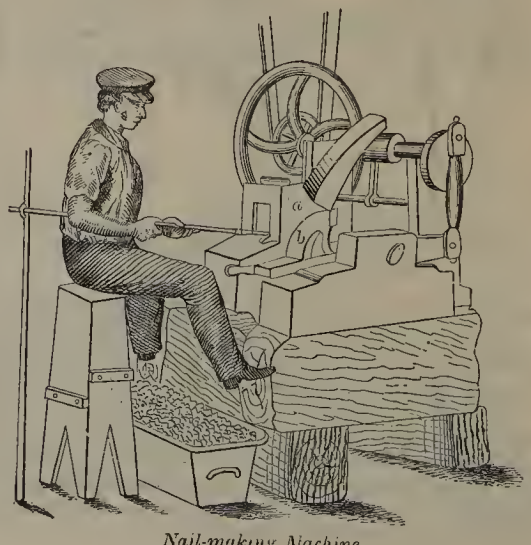
Perkins's machine, invented 1790 and patented in 1795, is said to have been capable of making 200,000 nails per day.

These, and Odiorne's, which embraced some improvements upon them, attracted great attention in England, where they soon came into extensive use.

At the close of the century, 23 patents had been granted for improvements in nail-machines.

In cutting nails from the plate, it is an object of primary importance to avoid waste of metal. This is effected either by rotating the plate 180°, or by changing the angle of the cutter at each stroke, cut-nails universally being made slightly tapering in one direction. For this purpose many varying forms of feeding-device have been invented, a few of which are illustrated.

Fig. 3286.

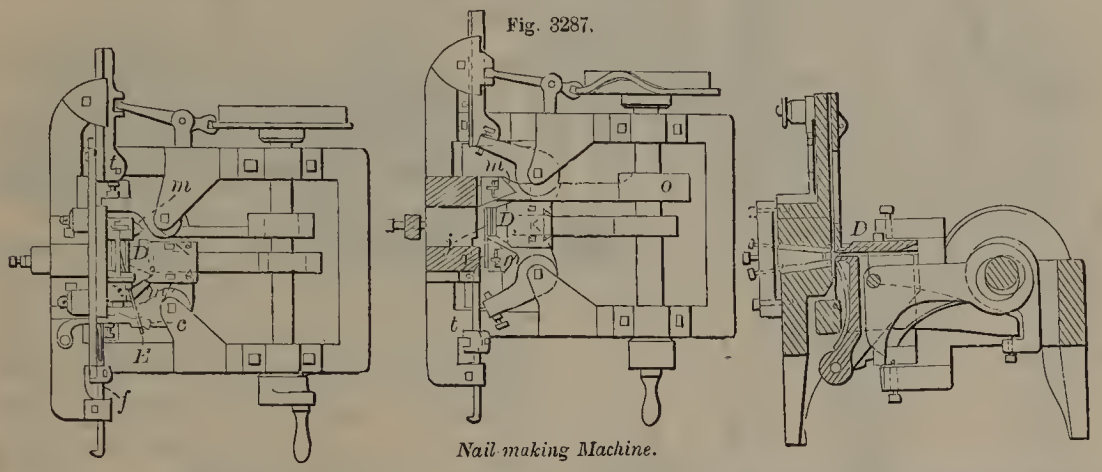


Nail-making Machine.

In Fig. 3286 the feeding is done by hand, the plate being turned by the operator. A lever operated by an eccentric on the shaft works the cutter inclosed in the box *a*, forming the nail-blank, which is then moved sideways and presented to the action of the lever *b*, by which the head is formed.

In the machine (Fig. 3287), two nails are cut from the sheet at once. On the forward movement of

Fig. 3287.



Nail-making Machine.

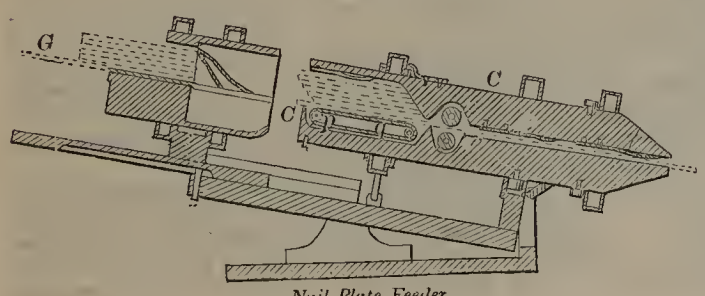
the punch *D* a projection is made to come in contact with an inclined block on the spring *E*, so as to force the latter against the blank while the punch is operating. The spring is held in position by a locking lever *c* until the punch is withdrawn, when a reciprocating stud *f* comes in contact with an arm on the locking lever and releases the spring. The fingers *j j'* which push the blanks between the grippers are held in reciprocating boxes *t* by springs, so as to slide if any undue resistance is met. The grippers *m m'* hold the cut blanks in position with the large ends projecting far enough for the headers to form the heads.

The illustration shows two plan views in different positions of the parts, and also a vertical longitudinal section.

In Fig. 3288, the nail-plates are placed in a box *G*, from which they are delivered to the hollow cylinder *C C*, and fed forward singly by the band-carrying rollers *p q* to the cutters. The cylinder is, by means of gears, moved half round after each cut, being withdrawn from the cutters by a cam movement.

In Fig. 3289, the nail-blanks, previously headed, are fed to the upper pair of rolls, which reduce the size of the body. The head is then seized by the second pair, arranged transversely to the first, by which it is still farther reduced, and so on successively, until the last pair, by which the nail is perfected, is reached. Each pair is grooved to correspond with the intended form of the nail, the grooves successively decreasing in size from first to last. The successive pairs of rollers act upon alternate faces, the rolls *a a*, etc., being at right angles to their alternates.

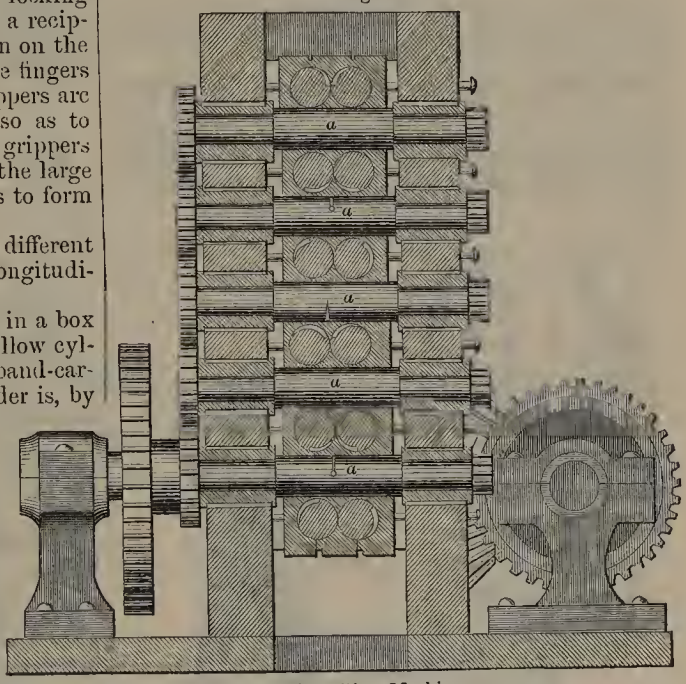
Fig. 3288.



Nail-Plate Feeder.

Wickersham's nail-machine produces a nail pointed like a chisel and tapered throughout its whole

Fig. 3289.

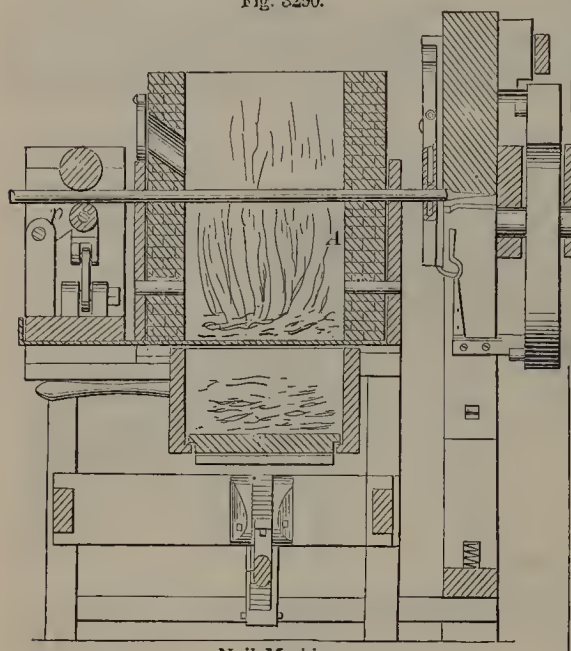


Nail-Rolling Machine.

length. A sheet of metal from 20 to 25 inches wide presents its edge to a series of cutters arranged around the periphery of a cylinder which cut simultaneously a row of nails from the entire edge of the sheet. The nails are cut and headed at one operation.

In Ward's machine (Fig. 3290), for making horseshoe or other wrought-iron nails, the rod *p* is automatically drawn by rollers through the furnace *A*, where it is brought to a forging heat, and is presented to the action of hammers while supported by an anvil. The hammers are operated by crank-arms and levers, which withdraw them from the iron, and at the proper moment permit springs to act upon them, forcing their acting faces, which

Fig. 3290.

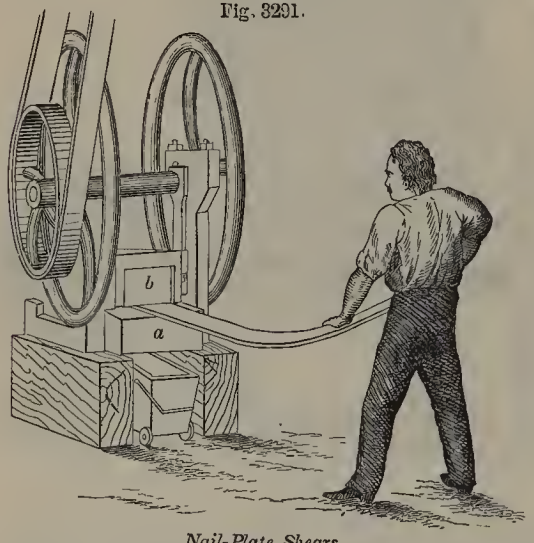


Nail-Machine.

are grooved to suit the shape of the nail, into contact with the red-hot rod, which is thus hammered on all four sides at once.

Nail-plate Shears. A machine for cutting nail-plates into suitable lengths to form nails. The plate is laid on the cutter-block *a*, and fed forward at each upward movement of the cutter *b* a distance equal to the length of the nail to be cut, from 2 *d.* to 60 *d.*

Fig. 3291.



Nail-Plate Shears.

The cutter is reciprocated in grooves in the standard by crank attachment to the fly-wheel, its downward movement taking off a slip from the end of the plate. The strip is received in a small car beneath.

Nail-scis'sors. Small scissors having files on the sides and used for trimming the finger-nails.

Nain-sook'. (*Fabric.*) A thick sort of jaconet muslin, plain or striped, formerly made in India. — Webster.

Na'ked Floor'ing. The parallel floor-joists, unboarded.

Na'ker. (*Music.*) A kind of kettle-drum.

Nan-keen'. Originally a fabric made from cotton of a yellow color (*gossypium religiosum*) and exported from Nankin, China. It is now made of white cotton, dyed by oak bark, arnotto, alum, etc., and sent from England to China. A part is, no doubt, reshipped in curious packages with the name of Li upon it.

Nap. 1. The pile of cloth.

2. The down of a hat.

3. *Naps.* The loops of velvet which are cut to make the pile.

Naph'tha-line. A substance formed during the destructive distillation of pit-coal.

Naph'tha-liz'ing. The enriching of poor gas, or carbureting of air, by passing either through naphtha or coal-oil.

Na'pier's Bones. Instruments invented by Napier for performing some of the fundamental rules of arithmetic by a mechanical process. They may be made of bone, ivory, horn, or wood. There are five of them, and the face of each is divided into nine equal parts, each being subdivided by a diagonal line into two triangles. In these compartments or squares the numbers of the multiplication-table are inserted, the units or right-hand figures being placed in the right-hand triangles, and the tens in the left.

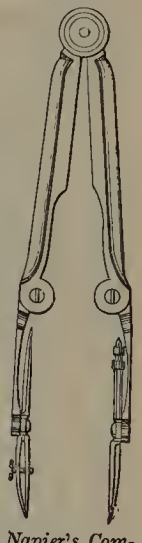
"Jonas Moore tells me the mighty use of Napier's bones, so that I will have a pair presently." — Pepys's *Diary*, 1667.

They were first described by the inventor, John, Lord Napier of Murcheston, in his "Rabdologiæ seu Numerationes per virgulas, Libri duo," ed. 1617.

> "A moon dial, with Napier's bones,
> And several constellation stones."
> Hudibras.

Na'pier's Com'pass. A draftsman's compass, to one leg of which is pivoted a plain point and pencil-holder, and to the other a plain point and pen. These fold in between the legs, so that the instrument may be carried in the pocket without inconvenience.

Fig. 3292.



Napier's Compass.

Nap'ping. (*Hat-making.*) A sheet of partially felted fur in a stage between the operation of the bow, which first distributes the fur in a light layer, and the *battery* at which it is united to the hat-body. It becomes the *nap* of the hat, which is raised by *carding* and shorn to a length.

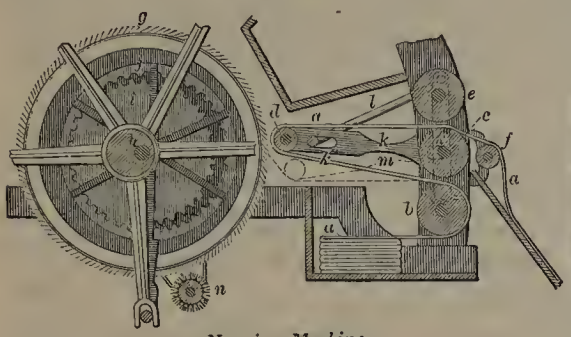
Nap'ping-ma-chine'. A machine for raising the nap or pile on woolen and cotton fabrics.

Fig. 3293 illustrates an improved form. In this the cloth *a a a* is drawn between the rollers *b c*, passing around the roller *d*, then between the rollers *c c*, and over the small roller *f* to a receptacle. These rollers, as well as the napping-cylinder *g*, are driven by the shaft *h*, which carries two eccentrics running loose upon it. The inner one of these is attached to the gear-wheel *i* on the napping-cylinder, which meshes with the internal gear *j*, causing an intermittent rotary motion. This movement causes a reciprocating motion of the arm *k* slotted at *k''*, the latter of these slots receiving the pivoted rod *l*, which is adjustably attached to a lever *m* (indicated by dotted lines) provided with a spring-pawl that engages with teeth on the central roller *c*.

In the operation of the machine, at each revolution of the driving-shaft the napping-cylinder is moved slightly forward, remaining momentarily stationary while the roller *d*, which presents the cloth to the napping-cards or teasels on the periphery

g, is moved eccentrically back and forth toward and from them, the ratchet device causing at the same

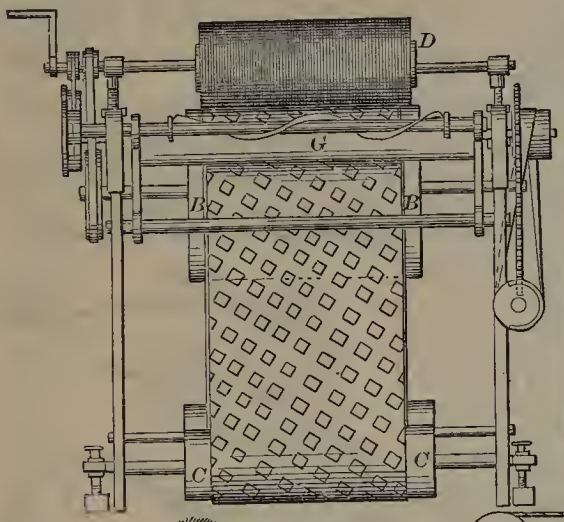
Fig. 3293.

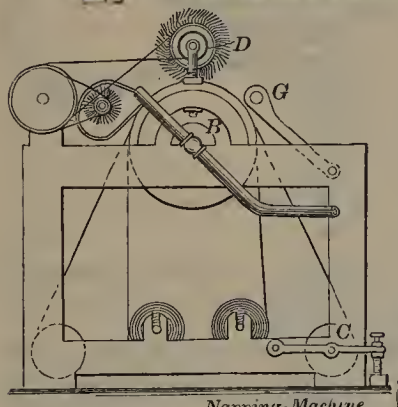


Napping-Machine.

time a partial revolution of the roller *c*, and presenting to the action of the cards a width of cloth equal

Fig. 3294.





Napping-Machine.

to that which is at the same moment withdrawn therefrom by the rollers *c c*.

The roller *d* admits of delicate adjustment to regulate the depth of nap raised.

n is a revolving clearer for removing fibers from the napping-cards.

Four series of the rollers are actuated at the same time by the movement of the shaft, so that four pieces of cloth are napped simultaneously.

In Fig. 3294, the rolls *C B* carry an endless band of thin sheet-metal stenciled with figures of any desired pattern. The fabric, which passes between the roller *B* and the endless band, is only exposed to the action of the napping-cards or teasels on the surface of the cylinder *D* at those points where the metal has been removed from the band; consequently, those parts only are napped, the rest of its surface remaining plain.

A shearing-device *G* of the ordinary kind may also be attached to the machine.

Nap-warp. (*Weaving.*) *Pile-warp.* In fustian weaving, the upper warp covering the main warp or nap.

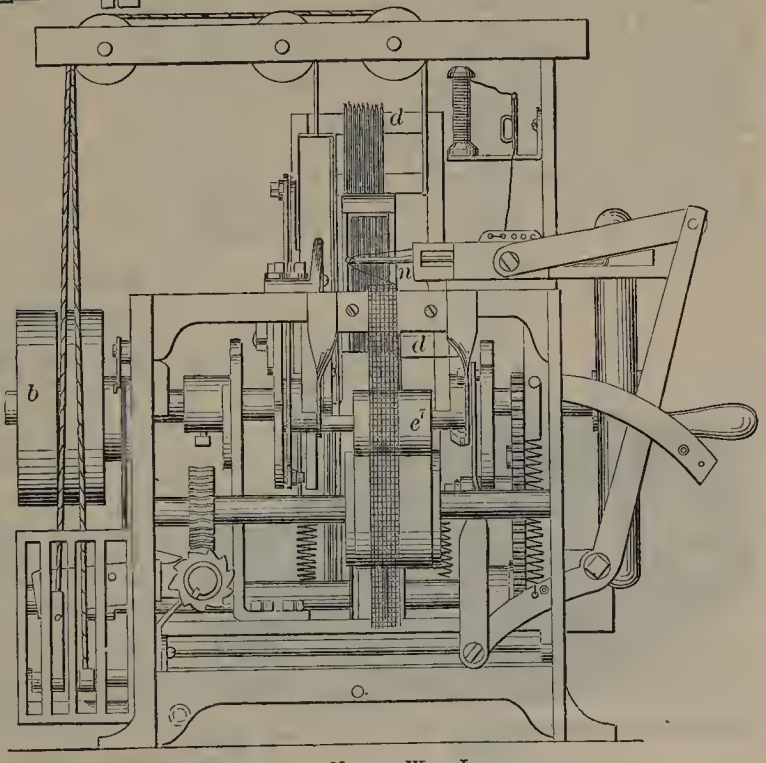
Nar-cot'ic-spray Ap'pa-ra'tus. A device for producing local anæsthesia. It consists of a bottle stopped by a perforated cork, through which passes a double tube, one of whose extremities reaches to the bottom of the bottle. Above the cork, a tube connected with a hollow sphere of india-rubber acting as a bellows penetrates the double tube and communicates through an aperture in the cork with the interior of the vessel. See page 93.

The operation of the bellows causes a current of air to descend through the aperture in the cork last mentioned, forcing the ether or other anæsthetic, with which the bottle is partially filled, to ascend through the inner branch of the tube, at the same time causing a current to pass through the outer tube, driving the ascending fluid before it, and depositing it in the form of spray upon the part under treatment. See ATOMIZER.

Nar'row Cloth. Woolen cloth under 52 inches width.

Nar'row-fab'ric Loom. Or, *narrow-ware* loom. One adapted specifically for weaving ribbons, tapes, bindings, etc. They are sometimes shuttle-looms, but usually have an eye-pointed needle which traverses the shed and back again between each movement of the harness. In the example, the filling-thread is carried double across the shed by a recip-

Fig. 3295.



Narrow-Ware Loom.

rocating eye-pointed thread-carrier, and then locked at the opposite selvage by passing a shuttle and its thread through a loop of such filling-thread. The loop is spread by the movement of the thread-carrier across the web.

n is the needle, receiving its weft-thread from the bobbin above. *d d* are the frames of the harness, operated by the cams shown at the lower left-hand corner of the figure. The picker motion is shown at the right, and consists of a bell-crank lever with connections to a cam-wheel and the needle-bar at its respective ends. c^7 and the rollers below it are the take-up. *b* is the band-wheel, through which motion is communicated by a belt from a prime motor. See also NEEDLE-LOOM.

Nar'row Gage. (*Railroad-engineering.*) One less than 4 feet 8½ inches in width between the rails, which is the usual distance between the wheels of locomotives and railroad-cars, as well as those of ordinary vehicles.

Railways of this description have been in operation in the Pennsylvania coal-region for more than thirty years, and have attracted great attention within the past few years, their advocates claiming for them much greater cheapness of construction, both of road and rolling stock, and greater economy of running expenses than can be attained on roads of the ordinary gage. Less excavation and embankment is necessary, a lighter rail is employed, and the cars are made much lighter in proportion to the weight they are capable of transporting. The narrow gages actually in use vary from 3 feet 6 inches to 2 feet.

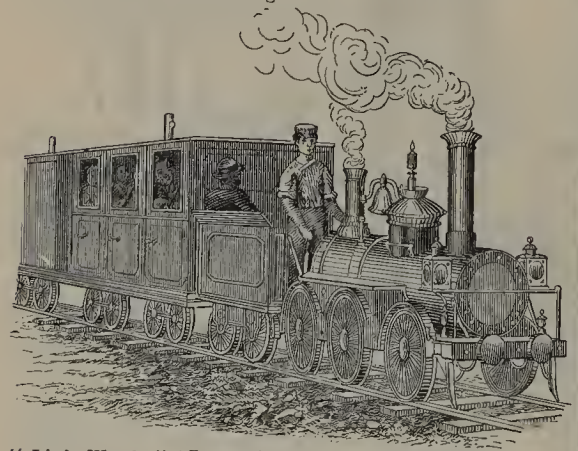
The Mauch Chunk road has a gage of 3 feet; this, the Nesquehoning, and the Carbondale roads, all narrow gage, were among the first of such gage constructed in this country.

Three feet six inches appears to be a favorite gage, those of Queensland, Australia, India, and Norway being all constructed of this width, the rails weighing from 35 to 40 pounds per yard.

Many engineers advocate a 3-feet gage or one even narrower for some purposes or localities. The narrowest in actual operation, so far as we are aware, only two feet, is the Portmadoc and Festiniog Railway in North Wales, through a very difficult country. This was originally designed as a tramway for the transportation of slate, stone, and other minerals from the hills of Merionethshire to the sea, but has since been used for passengers and general freight.

Fig. 3296 represents an engine, called the "Little Wonder," employed on this road. It weighs 19½ tons, and was first tested by a train 854 feet in length, consisting of 90 slate and 7 passenger cars, weighing 75 tons, constituting in all a load of 94½ tons, which it drew at a speed varying from 14½ to 26¼ miles an hour. Some of the curves on this road have a radius of but 1¾ chains. It is stated that an engine and tender weighing together only 10 tons is also used. The passenger-cars weigh 30 hundredweight each, and carry 12 passengers.

Fig. 3296



"*Little Wonder*" (*Portmadoc and Festiniog Railway, South Wales*).

This is an extreme example. Most of those of more recent date in this country are 3-feet gage. The locomotives and cars are similar in general construction to those employed on wide-gage roads, but much lighter and of greater capacity in proportion to their weight; a four-wheeled house-car on some Western roads weighing 4,000 and carrying 8,000 pounds, and costing $185 to $200. The passenger-cars seat 30 passengers, cost $1,000 and upward, according to style and finish. The locomotives weigh from 8,000 to 12,000 pounds, and cost $4,500 to $7,000. The rail weighs 32 pounds to the yard.

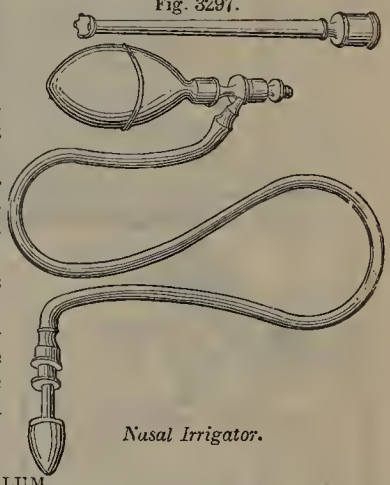
It seems to be conceded that for short roads and those required to accommodate but a moderate amount of traffic, the narrow gage possesses a decided advantage in point of economy, but for long roads transporting a large amount of freight and passengers and requiring high speed, 4 feet 8½ inches is by no means too wide a gage.

Nar'row-ing. (*Knitting.*) Contracting the fabric by throwing two stitches into one.

Nar'thex. (*Architecture.*) The first section in the Roman basilicas, set apart for monks and women, and devoted to certain religious ceremonies.

Na'sal Ir'ri-ga'tor. A syringe for nasal douches. In the illustration, the induction stem is shown detached, and the ejection end has a conoidal nozzle to fit the nostril.

Fig. 3297.



Nasal Irrigator.

Na'sal Spec'u-lum. (*Surgical.*) An instrument for distending the nostrils to expose the mucous membrane of the nose, and enable explorations and operations in cases of polypus, etc. See SPECULUM.

Nas-cale'. (*Surgical.*) A pessary of wool or cotton impregnated with a medicament for introduction into the vagina.

Nat'u-ral Steel. A steel obtained directly from the richer and purer kinds of ore by reducing them with charcoal and refining the cast-iron thus produced, so as to deprive it of a part of its carbon.

It is principally used for making files and other tools.

It is frequently termed German steel, being largely produced in Germany.

Na'ture-print'ing. A process in which impressions which may be printed from are obtained from objects, such as leaves, fibers, lace, etc.

In one method the object, such as a fern frond, is placed between a steel plate and one of heated lead and subjected to a strong pressure, forming an exact intaglio copy in the lead from which impressions are taken. This process was introduced by Auer of Vienna.

A process allied to the above consists in the application of successive layers of gutta-percha, — to fossil fishes, for instance, — and a mold obtained, which, being submitted to the action of a voltaic battery, is coated with copper, forming a plate on which all the markings of the fish are obtained in relief, the plate being used to obtain impressions by the ordinary typographic printing process.

By a third method the grain or markings of wood are transferred directly from the wood itself to paper, cotton cloth, etc. The wood is wetted with dilute acid and laid on the material; pressure transfers the markings of the wood to it, and it is then moderately heated, bringing out the colors.

One wetting suffices for twenty or thirty impressions.

Nau-ro-pom'e-ter. (*Nautical.*) An instrument for measuring the amount of a ship's heel or inclination at sea.

Nau'ti-cal A-larm'. See FOG-ALARM; BILGE-WATER ALARM; ICEBERG-ALARM; SHOAL-ALARM.

Nau'ti-cal Ap-pli'an-ces. See —

Accommodation ladder.
After-sail.
Alarm.
Anchor.
Anchor-ball.
Anchor. Drag
Anchor. Drift
Anchor. Mushroom
Anchor-tripper.
Apostles.
Apparel.
Arming.
Back-rope.
Back-stay.
Bag-reef.
Bails.
Balance-reef.
Ballast-shovel.
Balloon-jib.
Bangles.
Barking.
Beacon.
Bear.
Bearing-binnacle.
Becket.
Bee-block.
Bees.
Belaying-pin.
Bell-buoy.
Belly-band.
Bend.
Berth.
Bibbs.
Bight.
Bilge-water discharger.
Billet-head.
Binnacle.
Bird's-nest.
Bitter-end.
Bitts.
Bitt-stopper.
Blare.
Blast-engine.
Blind.
Block.
Block and tackle.
Blubber-guy.
Blubber-spade.
Boarding-nettings.
Boat.
Boat-detaching apparatus.
Boat-hook.
Boat-lowering apparatus.
Bob-stay.
Body-hoops.
Bollard.
Bolster.
Bolt-rope.
Bonaventure-mizzen.
Bon-grace.
Bonnet.
Booby-hatch.
Boom.
Boom-iron.
Boom-jigger.
Boomkin.
Boot-topping.
Bower.
Bow-fast.
Bow-grace.
Bowline.
Bowline-bridle.
Bowsprit.
Brace.
Brace-pendent.
Brail.
Breast-rail.
Breaming.
Breast-fast.
Bridle.
Bridle-port.
Broadside.
Bucklers.
Built-up.
Bull's-eye.
Bumkin.
Bunker.
Buntlines.
Buoy.
Buoy-rope.
Burgee.
Burr-pump.
Burton.
Cable.
Cable-gripper.
Cable-hook.
Cable-nipper.
Cable-shackle.
Cable-stopper.
Caburns.
Cant-block.
Cantick-quoin.
Canvas.
Cap.
Capstan.
Card.
Careening.
Cargo-jack.
Cargo-port.
Carrick-bend.
Carrick-bitt.
Cat.
Cat-block.
Cat-fall.
Cat-harping.
Cathead.
Cat-hook.
Cat's-paw.
Center-board.
Chafing-gear.
Chain-cable.
Chain-hook.
Chain-lifter.
Chain-pump.
Chain-stopper.
Cheeks.
Chess-tree.
Chest-rope.
Chinse.
Chinsing-iron.
Cleat.
Clew.
Clew-garnet.
Clew-line.
Clinch.
Clinching.
Clove-hitch.
Coat.
Collar.
Commander.
Compass.
Compressor.
Concluding-line.
Controller.
Cork-jacket.
Counter.
Counter-brace.
Courses.
Crane.
Creeper.
Cringle.
Cross-chocks.
Cross-jack yard
Cross-tree.
Crotch.
Crow-foot.
Crow's-nest.
Crupper-chain.
Cuddy.
Cup.
Davit.
Dead-eye.
Dead-head.
Dead-light.
Dead-sheave.
Deck.
Deep.
Deep-sea line.
Dog-stopper.
Dolphin.
Dolphin-striker.
Downhaul.
Drabler.
Drag.
Drag-anchor.
Drift-anchor.
Drift-sail.
Driver.
Drog.
Drum-head.
Dunnage.
Earing.
Electric buoy.
Electric log.
Euphroe.
Eye.
Eye-splice.
Fair-leader.
Fake.
Fall.
Fall and tackle.
Fancy-line.
Fang.
Fast.
Fender.
Fid.
Fid-hammer.
Fife-rail.
Filling.
Fish-davit.
Fish-fall.
Flake.
Fleet.
Flemish eye.
Flemish horse.
Floating-anchor.
Flying-jib.
Flying-jib boom.
Fog-alarm.
Foot.
Foot-rope.
Fore-and-aft sail.
Fore-ganger.
Forerunner.
Fothering.
Fox.
Frapping.
Furling.
Gaff.
Gallows-bitt.
Gammoniug.
Gang-board.
Gang-cask.
Gangway.
Garland.
Garnet.
Gasket.
Girtline.
Gooseneck.
Goose-wings.
Gore.
Grafting.
Grapnel.
Grappling-irons.
Graving.
Gripes.
Grommet.
Ground-tackle.
Guest-rope.
Gutter-ledge.
Guy.
Halser.
Halyard.
Hammock.
Hand-lead.
Hank.
Harness-cask.
Harping.
Hawse.
Hawse-block.
Hawser.
Hawser-clamp.
Head.
Head-fast.
Head-rope.
Head-sail.
Heart.
Heel-chain.
Heel-rope.
Hitch.
Hog-frame.
Holystone.
Hood.
Hoop.
Horse.
Horseshoe-rack.
Horsing-iron.
Houuding.
Hounds.
Housing.
House-liue.
Ice-anchor.
Ice-beam.
Inhaul.
Jack-block.
Jack-cross-tree.
Jack-ladder.
Jack-staff.
Jack-stay.
Jaw.
Jeer.
Jewel-block.
Jew's-harp.
Jib.
Jib-boom.
Jigger.
Jury-mast.
Keckliug.
Kedge.
Kennet.
Kentledge.
Kevel.
Kite.
Knights.
Knittle.
Knot.
Lacing.
Ladder.
Ladder-way.
Lanyard.
Larboard.
Lashing.
Lasket.
Latching.
Lateen-sail.
Lazy-jack.
Lead.
Leading-part.
Leak-indicator
Leak-signal.
Lee-board.
Leech.
Leech-line.
Leech-rope.
Lee-fang.
Lee-faunce.
Leeway-indicator.
Life-buoy.
Life-car.
Life-line.
Life-preserver.
Lift.
Link-worming.
Lizard.

Log.
Log-board.
Log-book.
Log-chip.
Loggerhead.
Log-glass.
Log-line.
Log-reel.
Loom.
Lubber's hole.
Luff.
Luff-tackle.
Luff upon luff.
Lug-sail.
Made-mast.
Main.
Making-iron.
Mallet.
Man-rope.
Marks and deeps.
Marline.
Marline-spike.
Martinet.
Martiugale.
Mast.
Mast-hoop.
Mast-scraper.
Mat.
Messenger.
Mizzen.
Monkey-rail.
Moon-sail.
Mooring-swivel.
Mouse.
Nautical signals.
Necklace.
Nipper.
Nock-oar.
Norman.
Nun-buoy.
Oar-lock.
Outhaul.
Outrigger.
Oyster-dredge.
Oyster-rake.
Oyster-tongs.
Painter.
Pala.
Palm.
Parceling.
Parceling-machine.
Parclose.
Parral.
Parral-rope.
Partner.
Paunch.
Pawl-bitt.
Pawl-rim.
Paying.
Peak.
Pennant.
Pin-rack.
Plummet.
Point.
Pole-mast.
Port.
Port-tackle.
Poy.
Preventer.
Prow.
Puddening.
Puoy.
Purchase.
Puttock shrouds.
Pyx.
Quant.
Quarter.
Quarter-block.
Rack.
Raddle.
Rafting and booming logs.
Raising-iron.
Ratline.
Rare-hook.
Reef.
Reef-band.
Reef-point.
Reef-tackle.
Reeming.
Reeming-beetle.
Relieving-tackle.
Rhodings.
Rhumb.
Ridge-rope.
Riding-bitts.
Rig.
Rigging.
Ring-bolt.
Ring-sail.
Ring-tail.
Ripping-iron.
Roach.
Roband.
Rolling-tackle.
Rope.
Rope-yarn.
Rough-tree.
Rounding.
Rowl.
Rowlock.
Rowport.
Royal.
Rubber.
Rubbing-paunch.
Rudder.
Rudder-chains.
Rudder-pendant.
Runner.
Running-rigging.
Saddle.
Sail.
Sail-clutch.
Sail-hook.
Sail-hoop.
Saucer.
Save-all.
Score.
Scotsman.
Scraper.
Screw-mooring.
Screw-steering apparatus.
Scull.
Scupper.
Scupper-hose.
Scupper-leather
Scupper-shoot.
Seam.
Seaway-measurer.
Seizing.
Selvage.
Selvagee.
Sennit.
Serving
Serving-mallet.
Settee-sail
Setting-pole.
Shackle.
Shackle-crow
Shears.
Sheep-shank.
Sheer-batter.
Sheer lashing.
Sheer-mast.
Sheet.
Sheet-anchor.
Ship's pendulum.
Shoal-indicator.
Shot-plug.
Shoulder-of-mutton sail.
Shroud-hawser-laid rope.
Shrouds.
Shroud-plate.
Shroud-truck.
Skeet.
Skipsail.
Skysail.
Sky-scraper.
Slab-line.
Slice.
Sliding-gunter
Slings.
Slip-hook.
Slip-shackle.
Slip-stopper.
Smiting-line.
Smoke-sail.
Snaking.
Snotter.
Sounding.
Sounding-apparatus.
Sounding-line.
Sounding-rod.
Span.
Span-block.
Spanish burton.
Spanish windlass.
Spanker.
Spar.
Speck-block.
Speed-indicator.
Spencer.
Spider.
Spike-tackle.
Spilling-line.
Splice.
Splicing-fid.
Splicing-shackle.
Spring.
Sprit.
Sprit-sail.
Sprit-sail yard.
Spun-yarn.
Spurling-line.
Square-sail.
Standing-rigging.
Starboard.
Stay.
Stay-sail.
Stay-tackle.
Steam-steering apparatus.
Steering-apparatus.
Steering-wheel.
Steeve.
Stern.
Stern-fast.
Stern-sheets.
Stirrup.
Stop.
Stopper. Cable
Stopper. Rigging
Storm-sail.
Strand.
Strap.
Stray-line.
Stream-anchor.
Stream-cable.
Streamer.
Stretcher.
Studding-sail.
Stump-mast.
Submarine thermometer.
Supporter.
Surge.
Swab.
Sweep.
Swinging-boom.
Tabling.
Tack.
Tackle.
Tack-tackle.
Tail-tackle.
Tell-tale.
Thimble.
Thimble-eye.
Thole.
Throat.
Thrum.
Thumb-cleat.
Thwart.
Tie.
Tier.
Tiller.
Tiller-rope.
Tilt.
Toggle.
Top.
Top-chain.
Top-gallant.
Top-hamper.
Top-mast.
Topping-lift.
Towing-bridle.
Train-tackle.
Trap-net.
Traverse-board.
Traverse-table.
Trawl.
Tree-nail.
Trestle-tree.
Tricing-line.
Triatic stay.
Trigger.
Tripping-line.
Truck.
Trundle-head.
Truss.
Try-sail.
Tuck.
Tumbler.
Turk's head.
Tye.
Undocking.
Uphroe.
Vang.
Velocimeter.
Vessel.
Voyol.
Waft.
Wall-knot.
Wapp.
Warp.
Watch tackle.
Water-anchor.
Water-line
Waterman's knot.
Water-sail.
Wheel.
Wheel-rope.
Whelp.
Whip.
Whip-on-whip.
Whisker.
Winch.
Windlass.
Wind-sail.
Wire-rope.
Wooden-wing.
Wood-lock.
Worming.
Yard.
Yard-tackle.
Yoke.

Nau'ti-cal In'di-ca-tor. An instrument invented and thus named by Hunter.

It consists of a stand supporting a circular plate of polished brass, about 14 inches in diameter, representing the horizon, and marked and numbered accordingly with the proper divisions. The horizon is surmounted by a semicircular plate, as a meridian, set at right angles to the plane of the horizontal plate, properly divided and furnished with an index attached to a nonius indicating minutes. This meridian plate is cut out at the center, to allow room for a pivot or hinge for other parts of the indicator. On one side of the meridian are placed two quadrants, and at the other side one, similarly divided as the meridian and furnished with a similar index and nonius. The quadrants are movable on a pivot or hinge, rising perpendicularly from the center of the horizontal plate, or agreeing to this center; they are singly movable on the pivot, but capable of being attached at any relative distance, and retained in that position by a screw, binding together tails attached for that purpose. To the east and west points of the horizontal plate is attached a horary circle divided into hours, etc. This horary circle represents the path of the sun, and it may be furnished with a nonius, as the other parts are. This circle is so attached to the horizontal plate that it can be moved

parallel to it, to suit the sun's declination. This is effected by the circle being attached to two tangent plates, which, by grooves, slide on the projections from the horizontal plate by means of screws passing through and working in these projections, and carrying the tangent plates, and with them the horary circle, to the degree of the sun's declination. This degree is indicated on a scale of tangent divisions on the tangent plates; and as such tangents are of various lengths, an expanding vernier is used to adjust them.

Nau'ti-cal Sig'nals. Signals for affording communication between vessels at sea or between vessels and the shore, consist of a system of flags of various colors for use by day or of lanterns at night, each separate combination and arrangement of which indicates some phrase or sentence that is or may be required in directing the evolutions of a fleet, the movements of a single vessel, making known the wants of the ship which displays it, or in replying to signals made by other parties. A more limited number of signals, sufficing for making known the most pressing necessities and for guiding a vessel into port when unprovided with a pilot, are made by the use of a single flag, attached to a staff, which is waved to the right or left, held vertically, or reversed, to express different meanings.

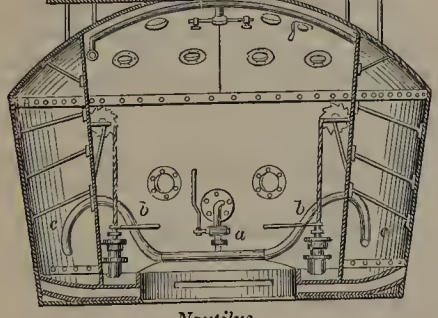
These combinations are depicted in books and numbered, so that, on seeing a particular signal hoisted, a party in possession of a similar book can, by reference thereto, ascertain the number of the signal and its meaning.

Those used by war-vessels differ with each nation, and the books containing them are covered with canvas lined with sheet-lead, so that in case of capture by an enemy they may be thrown overboard and sunk. The code of signals adopted by the British Admiralty requires the use of fifty flags.

For the merchant service the number of combinations required is much less. The code introduced by the late Captain Marryatt, R. N., was in general use until 1857, but is now superseded by that adopted by the British Board of Trade. This requires the use of only eighteen flags, by which 20,000 signals may be made, and numbers up to 70,000 represented. These numbers are printed in a book, and to each a word or sentence is attached.

Nau'ti-lus. A European form of diving-bell. It requires no suspension. Water admitted through

Fig 3298.



Nautilus.

the cock *a* into the pipes *b b* flows into the exterior chambers *c c*, causing the apparatus to sink. The workmen enter through an aperture at the top, closed by an air-tight cover, and can in still water move the machine in any required direction by stepping on the ground and pushing. Air is condensed in a reservoir at the surface to a degree somewhat greater than the condensation due to the depth, and passes through a pipe into the chambers *c c*, rendering the machine specifically lighter than water and enabling it to lift stones or other objects below. A gage indicates the amount of lifting power attained as the air is admitted, so that the supply may be cut off when the requisite power is attained.

Nau'ti-lus-pro-pel'ler. A device for propelling ships, so named by Mr. Ruthven. A large iron chamber containing water is placed in a suitable part of the ship. This contains a horizontal turbine-wheel rotated by a vertical shaft from the engine. The rotation of the wheel impels the water through two pipes outwardly to each side of the ship, where it escapes through two nozzles which may be directed either toward the stern or bow of the vessel, causing her either to go ahead or back, as the case may be. This motion of the nozzle is rapidly effected by means of a handle on deck. The two nozzles may be pointed in different directions, so as to cause the ship to turn on her center. The motion of the turbine does not require to be reversed, the backward or forward motion of the vessel being entirely controlled from the deck.

The apparatus has been tried by the British Board of Admiralty on the "Water Witch," a vessel of 800 tons. The result was a success so far as a reasonable speed was concerned, but the device was not regarded as equal to the paddle or propeller as a means of propulsion.

The idea is very old, has been tried a number of times, and proposed much more often. See HYDRAULIC PROPELLER.

Nave. 1. (*Vehicle.*) The central portion of a wheel from which the spokes radiate. See HUB.

2. (*Architecture.*) The main body of a church.

Na'vel. (*Ordnance.*) A perforated lug on the under side of a carronade which is engaged by a through bolt and thereby secured to the carriage.

Na'vel-hood. (*Shipwrighting.*) A hood wrought above the exterior opening of a hawse-hole.

Neb'ule-mold'ing. (*Architecture.*) An ornament of the zigzag form, but without angles; it is chiefly found in the remains of Saxon architecture, in the archivolts of doors and windows.

Neck. 1. A narrowed portion of an object relatively near to the end; as of a bottle, an axle.

2. (*Chemistry.*) The beak or rostrum of a retort.

3. (*Ordnance.*) *a.* The part joining the knob of the cascabel to the base of the breech; called the *neck of the cascabel.*

b. The small part of a gun where the chase meets the swell of the muzzle.

4. (*Music.*) The finger-board between the head and the body of a violin, guitar, banjo. Upon the *neck* the strings are pressed by the fingers in playing. Some *necks* have *frets;* the guitar, for instance.

5. (*Architecture.*) The narrow part between the astragal of the column and the annulet of the capital.

6. The jib of a crane.

7. A tubular projection to receive a collar, as that on a stove which receives a pipe.

8. A short shaft.

A diminished portion of a shaft where it rests in the bearing.

9. An intervening and connecting portion; as, the *neck* of a bayonet connecting the *blade* and *socket.*

10. A *goose-neck;* a flexible joint between a hose or pipe and a nozzle.

11. (*Nautical.*) A portion connecting the collar on the yard-arm and the iron of the studding-sail boom.

12. The narrower part of an embrasure. The *mouth* is the outer or *wider* part.

13. (*Metallurgy.*) The contracted portion of a furnace between the heating or melting chamber and the *stack*, passing over the *bridge*.

Neck'lace. (*Nautical.*) *a.* A strap round a mast carrying leading-blocks.

b. A chain to which the lower ends of the futtock-shrouds are secured.

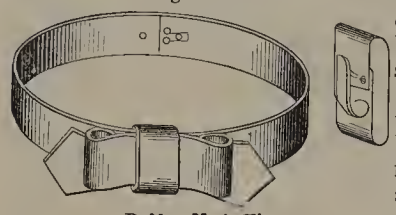
Neck-mold. (*Architecture.*) A small convex molding surrounding a column at the junction of the shaft and capital.

Neck-strap. (*Harness.*) *a.* A strap round the neck of a draft horse; a temporary expedient.

b. A halter strap around the neck. A part of a martingale.

Neck-tie Re-tain'er. A clasp to attach the tie to the neck or to the button of the neck-band of the shirt.

Fig. 3299.

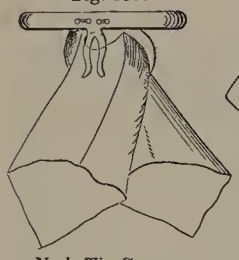


Rubber Neck-Tie.

Neck-ties are usually of ribbon or some fabric, but sometimes of vulcanite, as in Fig. 3299.

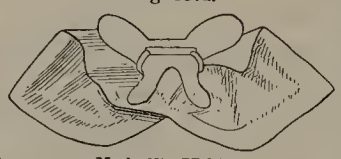
In Fig. 3300, the tie is sewn to an elastic plate, which passes beneath the collar and has a pair of elastic jaws projecting downward from its lower edge to embrace the button.

Fig. 3300.



Neck-Tie Supporter.

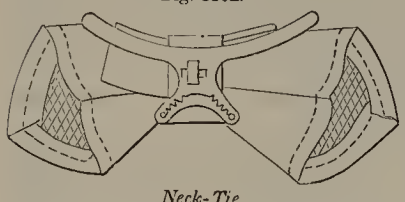
Fig. 3301.



Neck-Tie Holder.

In Fig. 3301, the forks straddle the button attachment, and the wings slip under the lappel of the collar.

Fig. 3302.

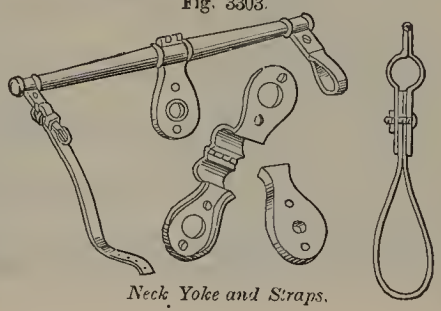


Neck-Tie.

In Fig. 3302, the slotted retainer is secured to the shirt collar or button, and the pin attached to the bow or scarf is caused to interlock therewith.

Neck-twines. (*Weaving.*) In fancy weaving, small strings by which the *mails* are connected with the *compass-board*.

Fig. 3303.



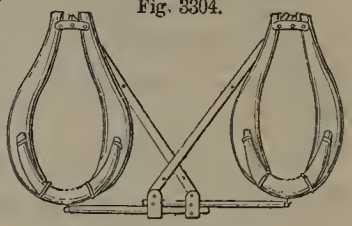
Neck Yoke and Straps.

Neck-yoke. A bar, usually of wood, by which the end of the tongue of a wagon or carriage is supported. The *breast-straps* or *chains* pass through the rings on the hames, or, in the case of carriages, the straps pass around the lower part of the collar.

Animals in ancient Egypt were universally attached to their work by yokes. This was the case with horses, asses, or oxen, to wagons, chariots, or farming implements.

In a modified form, hinged plates are clasped around the neck-yoke, and the central clasp has plates perforated to receive the end of the tongue. Leather is inclosed between the two plates. The end straps are secured to the neck-yoke by metallic straps.

Fig. 3304.



Draft Neck-Yoke.

The cut shows the several parts.

Fig. 3304 shows a draft neck-yoke in which the collars are braced together and to a rod which is secured to the tongue, so that the draft is by the latter, dispensing with traces.

Nee'dle. 1. A pointed instrument for carrying a thread through a fabric, leather, or paper. It usually passes through the fabric and drags the thread after it, but it is otherwise with eye-pointed needles, such as packing-needles, and those in sewing-machines. The last-mentioned are really awls.

Needles of bone are found in the caves occupied by the ancient inhabitants of France during the stone period, and the same material is in use among uncivilized tribes at the present day.

The needles of ancient Egypt, as described by Wilkinson, are of bronze, and no eye is apparent in his illustration of them. It would rather seem that the thread is attached to a circular depression near the blunt end. It would be hardly reasonable to doubt that they had needles with eyes. We know from Scripture and secular history and from the tapestry that has survived thirty centuries that they were skillful and painstaking seamstresses.

> "A woman must not go out on the sabbath
> With a needle that has an eye."
>
> MISHNA.

The Phrygians and Hebrews held fine needlework in high estimation. Needles of bronze were used by the Greeks and Romans, are described by Pliny, and have been found in Herculaneum.

The history of art progress during the Middle Ages is a blank, but we find that needles were manufactured at Nuremberg in 1370. The history of their manufacture in England is involved in doubt, but it is said to have been introduced about 1543–45, either by a Spanish negro or a native of India, who died without disclosing the secret of his process. It was recovered during the reign of Elizabeth, by Growse, a German.

In 1650, Christopher Greening and a Mr. Damer established needle-factories at Long Crendon, near Redditch, and were soon followed by other needle-makers from London.

Redditch is yet the great center of the English needle manufacture.

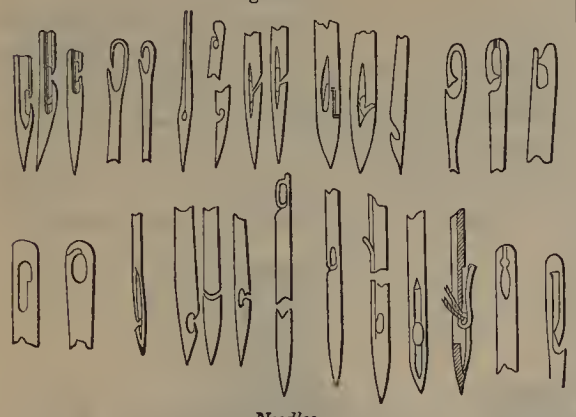
The earliest needles were "square-eyed," that shape being most readily produced. "Drill-eyed" needles, after many unsuccessful attempts, were first brought out in 1826. The burnishing machine, in which the needles are strung on a steel wire to which rapid revolution is imparted, was introduced two

years later. By this, a beautiful finish is imparted to the eye. The process of hardening them in oil was introduced in 1840, water having been previously used for this purpose, which caused a large proportion of them to become crooked, requiring the services of a large number of workmen to straighten them. These being thrown out of employment by the new process made a riot and drove its introducer out of town, but it was finally generally adopted. A similar disturbance had taken place in 1830, on the introduction of the stamping-machine. The machine for pointing is of still more recent introduction.

A needle with a point at each end and an eye at the middle of its length was patented in England in the year 1755, for hand-sewing or embroidering, the patentee describing it as used by holding it with the fingers at the middle of its length, so that it will not require turning. In 1829 it was successfully introduced into an embroidering-machine, which is still in extensive use. As many as one hundred and thirty such needles, worked by pincers on opposite sides of the fabric to be embroidered, are used in a single machine. In 1842 a sewing-machine inventor adopted the same kind of needle, and some others have made sewing-machines with such needles, but no such machines have ever been successful.

The accompanying cut shows a number of patented needles, some with eyes near their points, some

Fig. 3305.



Needles.

having means of slipping the thread into the eye without reeving.

Needles are known as *sharps*, *betweens*, *blunts*, according to the relative fineness of their points.

The so-called *golden-eyed* needles are tinted by dipping in an ethereal solution of gold.

The *silver-eyed* needles are not really silvered, but the silvery hue is given by a peculiar polish.

The *blue-pointing* is a dark polish effected by applying the needles to a revolving stone of a bluish color.

The *drilled-eyed* needles have the eyes finished by a countersink drill, the eye end being previously softened.

Bell's *needles*, English patent, are made of steel, *cast* in sand molds.

The mode is particularly intended for bodkins, fish-hooks, knitting, netting, packing, and sail needles.

2. (*Surgical.*) The *acupuncture*-needle is a gold or silver needle, four inches long, with a handle. See ACUPUNCTURATOR.

The *cataract*-needle is a steel, inflexible needle, 15 to 24 lines long, and is employed to depress or tear the opaque crystalline lens. The extremity may be as in Scarpa's and Langenbeck's, pointed, prismatic, triangular, and curved. In Duputren's and Walther's, flat, curved, and sharp-edged. In Hey's, flat, with a sharp end. In Beer's, Siebold's, Schmidt's, Himly's, Von Gräfe's, straight and spear-pointed. A mark is placed on the handle to indicate the side corresponding to the crystalline when the instrument is in the eye.

The *counter-opening* needle, or *acus invaginata*, is a long, narrow steel needle with a point sharpened on both sides. The heel has an aperture to receive a thread or tape. It has a sheath to cover the point in passing critical places.

The *fistula*-needle is a flat, flexible silver instrument, with a point at one end and an eye at the other to lead in a seton. Its side is grooved to form a leader for a bistouri. Also a steel instrument like a trocar.

The *hare-lip* needle is a small silver canula with a spear-point.

The *ligature*-needle has a point and eye, and was formerly used to pass a ligature around the artery and a portion of the integuments to suspend circulation prior to amputation. Or a steel curved needle with a lance-point and long eye to pass a ligature around a vessel. See LIGATURE-CARRIER.

The *scton*-needle, a long, narrow steel blade with a point and eye.

A *suture*-needle. For a twisted suture the hare-lip needle; a straight needle for stitching up after dissection; or a curved needle, flat on one side and with a sharp ridge on the other.

See also ACUS.

3. (*Nautical.*) *a.* The seaman's and sailmaker's needles are *scaming*, *bolt-rope*, and *roping* needles; they are three-sided.

b. The polarized steel of a mariner's compass.

4. (*Sewing-machine.*) The eye-pointed instrument for carrying thread through the cloth.

5. (*Weaving.*) A horizontal piece of wire with an eye to receive the lifting-wire in a Jacquard loom. See JACQUARD; PATTERN-CARD.

6. (*Hydraulic.*) One of a set of vertical square bars of wood in a timber frame in a weir. These *needles* stand close together, and close the opening which forms a sluice-way. They are capable of being removed separately to open a way for the water.

7. (*Hoisting.*) A beam projecting from a building, with a pulley at its outer end, the *fall* worked by a crab placed inside the building.

8. A tool for pricking the cartridge to make connection between the charge and the priming. See BLASTING-TOOLS.

See under the following heads: —

Aneurism-needle.
Astatic needle.
Betweens.
Blasting-needle.
Blunts.
Bolt-rope needle.
Cataract-needle.
Crochet-needle.
Darning-needle.
Dipping-needle.
Epinglette.
Etching-needle.
Fissure-needle.
Knitting-machine.
Ligature-carrier.
Magnetic needle.
Mariner's-compass needle.
Needle.
Needle-beam.
Needle-case.
Needle-forceps.
Needle-guard.
Needle-gun.
Needle-making machine
Needle-telegraph.
Needle-threader.
Needle-wrapper.
Nerve-needle.
Netting-needle.
Roping-needle.
Sewing-machine needle.
Sharps.
Surgical needle.
Tag.
Tatting-shuttle.
Threader.

Nee'dle-bar. 1. (*Knitting.*) In a stocking-frame, a bar in which the needles are fitted with their leads.

2. (*Sewing-machine.*) The reciprocating bar to whose end the needle is attached.

Nee'dle-beam. (*Civil Engineering.*) A trans-

verse floor-beam of a bridge, resting on the chord or girders, according to the construction of the bridge.

Nee'dle-bear'er. (*Surgical.*) A *porte-aiguille* forming a handle for a needle.

Nee'dle-car'ri-er. (*Surgical.*) A *porte-aiguille.*

Nee'dle-case. A book or wrapper in which needles are kept in the pocket or the work-table.

Nee'dle-file. A long, round, narrow file used by jewelers.

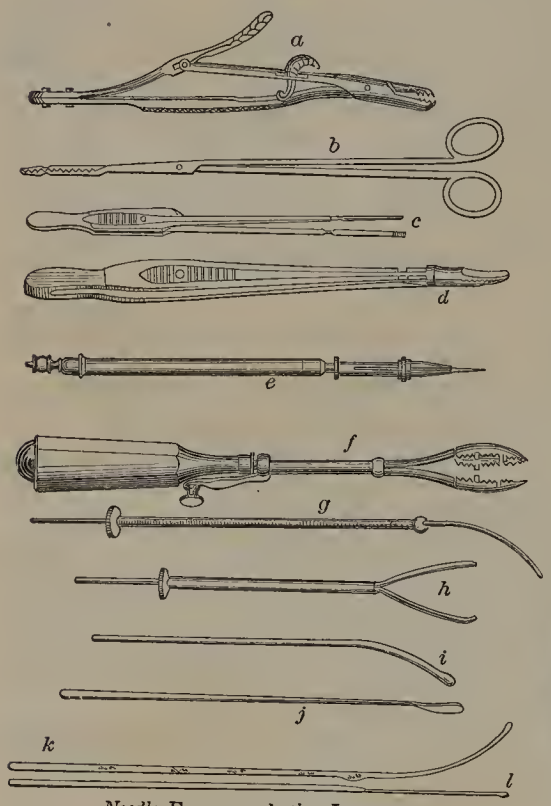
Nee'dle-for'ceps. An instrument to hold a needle to sew up wounds that cannot be reached by the hand, such as in vesico-vaginal fistula or uterine operations, or to hold very minute needles in operations about the eye or in staphyloraphy.

Sands's and Sims's, late American inventions, rank among the best.

a is a locking forceps.

b c d are forms used for general purposes of driving and holding needles, catching and twisting silver wires, applying and moving sponge-tents, etc.

Fig. 3306.



Needle-Forceps and other Instruments.

e is a draftsman's needle-holder.

f is a modification of Roux's needle-holder, which may be used in the operations of vesico-vaginal fistula, cleft palate, etc., and is made to serve as a handle to the instruments accompanying it, and which are manufactured one half their full length. When the handle is applied to either one it gives it its full length.

g combines the *applicator* with the sponge-tent expeller.

h is a sponge-holder and ligating forceps.

i, a lead sound, which easily follows the curve of the uterus.

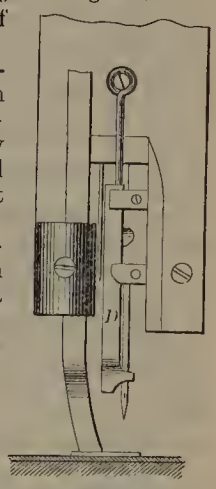
j, intra-uterine scarifying knife, blunt point.

k, Simpson's sound.

l, uterine probe of silver.

Nee'dle-guard. (*Sewing-machine.*) A sliding piece which moves with the needle and keeps it in line during rapid movement, so that it shall not strike wide of the hole in the cloth-plate.

Fig 3307.



Needle-Guard.

That in the example is a supporting brace or bar *D*, which slides vertically. In this instance, as the feed is effected by the needle, the bar has a lateral movement coincident with that of the needle.

Nee'dle-gun. (German, *Zündnadelgewehr.*) A fire-arm which is loaded at the breech with a cartridge carrying its own fulminate, and which is ignited by a *needle* or pin traversing the breech-block and struck by the hammer.

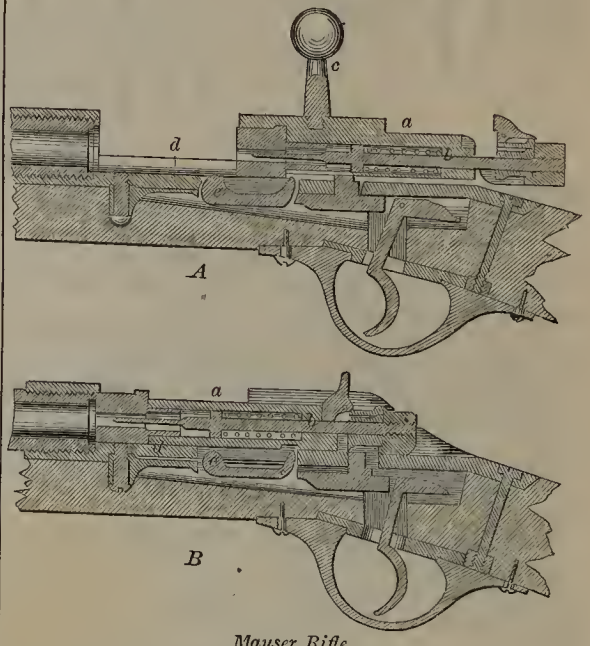
There are many guns of this construction, such as the converted Enfield (see CONVERTING); but the one which has attained so great celebrity, though by no means the best of its class, is the Prussian needle-gun, which performed so effective a part in the Prusso-Austrian war of 1866. See FIRE-ARM, cut *C*, Plate XVI. The French chassepot-gun is shown at *B*, same plate.

The Prussian piece was invented by Mr. Dreyse, who is said to have spent over thirty years in trying to construct a perfect breech-loading fire-arm.

It was introduced to some extent into the Prussian service about 1846, but was much improved afterward. It has since been superseded in the North German army by the Mauser rifle (Fig. 3308). *A* shows the breech mechanism in position for loading, and *B* at half-cock.

The breech-piece *a* is perforated to receive the needle *b*, and is operated by the lever *c*, by which it is turned quarter round and drawn backward,

Fig. 3308.



Mauser Rifle.

retracting the needle until a catch thereon drops into a notch by which it is retained until released by the action of the trigger, when it is driven forward by a spiral spring.

An extractor works in a groove at the side of the shoe *d*, withdrawing the cartridge-case when the

breech-piece is drawn backward. This movement brings the case in violent contact with the ejector *e*, by which it is thrown out.

A Berlin correspondent of the London "Times" gives an account of the performance of this new arm: "On a distance of 1,500 metres (1,640 yards), out of 480 shots, 399 hits were effected in five targets placed behind each other; and on 1,400 metres (1,564 yards), out of 480 shots, 460 hits are reported."

Nee'dle-hold'er. 1. A draftsman's instrument for holding a pricking-through needle. (*e*, Fig. 3306.)

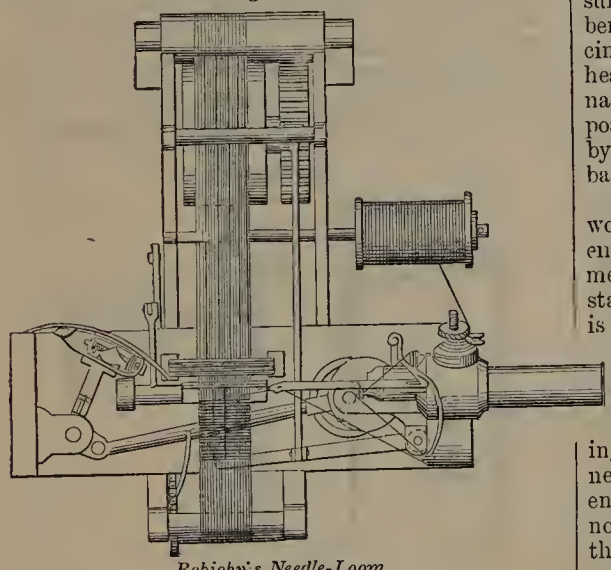
2. A surgeon's appliance for holding needles during operations. See NEEDLE-FORCEPS.

Nee'dle-in'stru-ment. (*Surveying.*) One which owes its accuracy and value to the magnetic needle only, such as the *plain* or the *Vernier compass* or the *Vernier transit.*

Nee'dle-loom. One in which the weft is carried by a needle instead of a shuttle. The usual form of loom for narrow wares, such as ribbons, tapes, bindings, etc. In the example, the filling is carried through the shed by a reciprocating eye-pointed needle, and the loop of the weft locked at the selvage by the passage through it of a shuttle and its thread. The weft-retractor swings freely on a pin; its shorter arm, when thrown fully back by a projection, rests in a notch on the needle-guide, until the pull of the needle passing through the shed detaches it and draws the retractor forward, taking up yarn from the bobbin.

The shuttle operates in an arc of a circle parallel to the plane of the warp, so that in approaching to enter the loop of the weft-yarn it moves nearly parallel with and close to the selvage of the web being woven, and afterward gradually moves away

Fig. 3309.

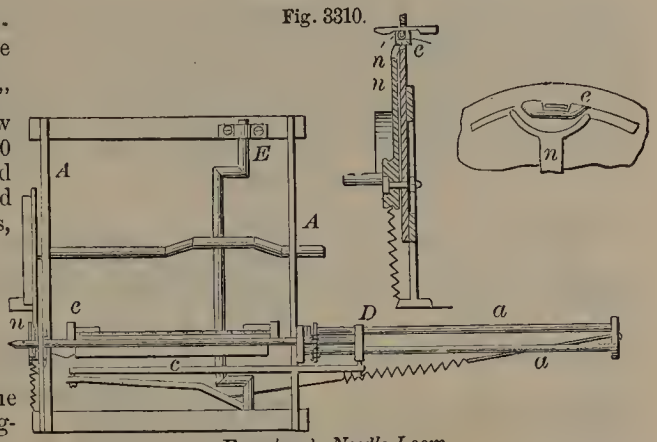


Robjohn's Needle-Loom.

from the warp, so that in completing its movement at the same time as the needle completes its retiring movement it pulls its yarn or thread tight in a direction transverse to the warp.

In Fig. 3310, the needle is eye-pointed and the weft-thread is carried by it in lieu of a shuttle. A shuttle-thread engages the loop, and the rod is retracted, leaving two filling-threads in the shed. The needle-stock *D* slides on bars *a a* projecting from the side of the loom, and is actuated by a rocker-shaft *E*, a vibrating arm *c*, and connections. The ordinary cap-piece of the reed is removed to permit

Fig. 3310.



Earnshaw's Needle-Loom.

free manipulation of the warp. The shuttle *e* has a segmental guide groove, and is operated by a divaricated arm upon a rocker-shaft *n*, its two horns engaging the back end of the shuttle alternately.

In Jackson and Merrill's needle-loom, the weft-thread is carried by a needle through the shed and is interlocked by a shuttle-thread, returning to its normal position before the shed changes. The needle is passed through the under part of the shed near the reeds, so as to preserve it from contact with the warps. The needle then receives a swinging movement that passes its end around a standing shuttle or bobbin, the needle returning through the shed near the point of weaving, so that the lay has to move the weft-thread but a short distance.

See also RIBBON-LOOM; NARROW-WARE LOOM.

Nee'dle-mak'ing. Needles are made from soft steel wire, which is received from the manufactory in coils. The wire is cut by fixed shears into lengths sufficient to make two needles; these blanks, being bent, require straightening, which is done by placing several thousands of them between two broad heavy rings and heating them to redness in a furnace. They are then removed, and placed, still in position within the rings, on a flat iron plate, and by means of a curved bar, termed a *smooth file*, rolled back and forth until perfectly straight.

Each piece is then sharpened at both ends. The workman takes up a number at a time and holds the ends against a grindstone, forming the points. By means of a die and counter-die, two grooves are stamped by a press on each side of the wire, which is next pierced under a press with two holes, forming the eyes. A number of pieces are then strung on two fine wires and broken each in two by filing and bending. The roughness about the head is removed by filings, several at a time being placed in a small vise. During these processes the needles, having become somewhat bent, are straightened by rolling on a flat plate, as before. They are now brought to a red heat, and tempered by plunging them into oil. 50,000 at a time are then put in a canvas bag with emery, oil, putty-powder, and soft-soap, and rolled to and fro under pressure until they become bright.

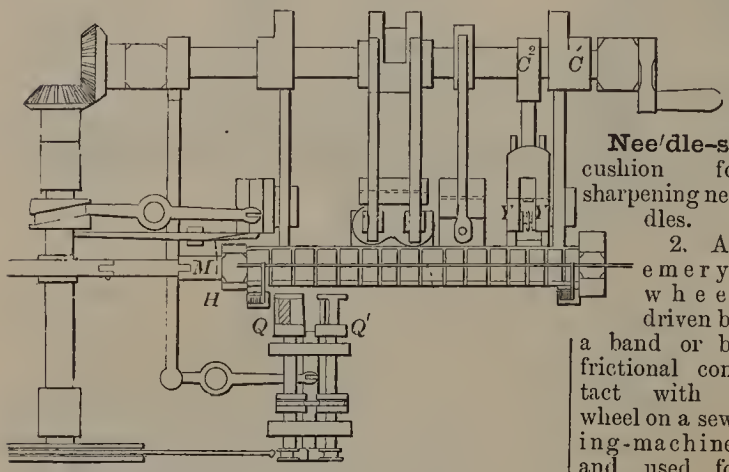
The better class of needles have their eyes drilled. The final process is polishing the points, which is effected first by a rotating hone and afterward by a buff-wheel.

Nee'dle-mak'ing Ma-chine'. Of late years machines have been introduced by which needles are formed from the roll of wire without the intervention of hand labor.

Fig. 3311 illustrates Barton's machine. In this, the wire is fed forward to a rack *M*, and cut to

length by the cutter *H*, being received in a groove of the bed-piece below the rack. The rack has a reciprocating movement both longitudinally and vertically; the latter serving to pick up the blank from each groove in the bed-plate, and the former to advance it to the next groove. At each groove it is

Fig. 3311.



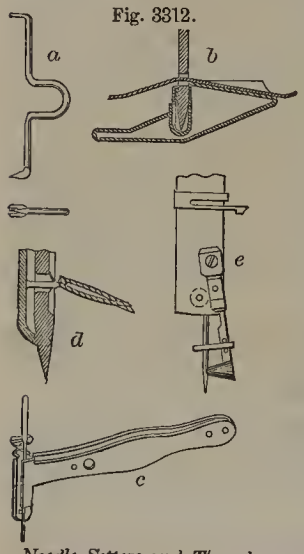
Needle-Making Machine.

subjected to the action of a die or punch, which dies successively form the groove for the eye and punch the eye. These are operated by the cams C^1 C^2, etc. It is then in the same way advanced, so as to be milled by the milling-tool *Y*, after which it is brought back, and while partially held by the reciprocating rack its point is finished by the revolving sharpeners *Q Q'*.

Nee'dle-pa'per-ing Ma-chine'. (*Metal-working.*) The needles are placed point foremost in a hopper whose bottom is divided by partitions forming spaces corresponding in width to the length of the needles. The hopper has a traversing motion by which the needles are arranged in rows, and on arriving at the proper point a pusher is caused to strike the end of each row, sticking the needles in the paper, which is advanced and crimped as they are presented to it.

Nee'dle-point'ing Ma-chine'. This comprises a grooved grindstone, to which the wires, cut to the desired length, are applied by an inclined plane. A disk covered with rubber revolves transversely to the grindstone, turning the needles round so as to present each point of their circumference to the stone, at the same time continuously furnishing a fresh supply for its action.

Fig. 3312.



Needle Setters and Threaders.

Nee'dle-set'ter. An attachment to a sewing-machine to allow the needle to be set in its bar, so that the eye of the needle shall be at the proper distance from the end of the bar, in order that the loop may be properly formed and at the right place for the hook or shuttle beneath the fabric. Fig. 3312 shows several forms.

a is a trial bar, whose upper end rests against the needle-bar and its lower point in the eye of the needle.

b is a shield which fits against the eye of the needle and has a channel to lead the thread.

c is a clasp to hold the needle, a point determining the position of the latter in the clasp which is placed against the needle-bar in adjusting the needle.

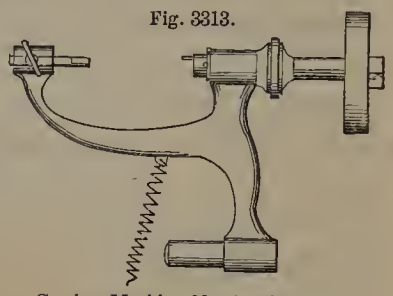
d has a bar with a hook to draw the thread through the needle-eye.

e has a latch which is brought down when required to indicate the adjustment of the needle in the stock.

Nee'dle-sharp'en-er. 1. An emery cake or cushion for sharpening needles.

2. An emery-wheel driven by a band or by frictional contact with a wheel on a sewing-machine, and used for pointing needles.

Fig. 3313.



Sewing-Machine Needle-Sharpening Attachment.

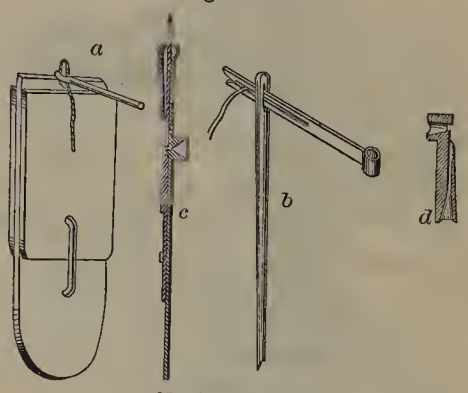
Nee'dle-tel'e-graph. A telegraph in which the indications are given by the deflections of a magnetic needle whose normal position is parallel to a wire through which a current of electricity is passed at will by the operator.

In practice, the needle is rendered astatic (see ASTATIC NEEDLE), and inclosed by a coil by which the effect of the electric current is multiplied. This is the principle of the *galvanometer* and of the electric telegraph of Cooke and Wheatstone, which is used in England. See INDICATOR-TELEGRAPH.

Nee'dle-thread'er. A device to assist in passing a thread through the eye of a needle. There are two kinds, and many varieties of a kind.

a is a form in which the thread is caught in a

Fig. 3314.



Needle-Threaders.

crotch and pushed through the eye of the needle.

In *b* it is caught by barbs and drawn through the eye.

In *c* and *d* the needle is adjusted opposite to a cone which directs the thread.

Nee'dle-wrap'per. A case or housewife to hold needles for the pocket or work-table.

Neg'a-tive. 1. (*Photography.*) A picture upon glass, in which the lights and shades are exactly reversed; the actual shades being represented by the transparent glass, the lights of the object show-

ing dark by the opaque material (reduced silver) on the glass.

The *negative* is used to obtain *positives*, being laid upon the sensitized paper which is acted upon by the sun's rays passing through the glass. The rays being but little impeded by the transparent portions make the darks of the *positive*, and being intercepted by the opaque silver make the lights and light shades of the positive picture.

Negatives are usually taken on glass coated with a film of collodion, which is sensitized for the purposes of the camera. The principal use of negatives is for obtaining positive prints.

2. (*Electricity.*) The metal or equivalent placed in opposition to the *positive* in the voltaic battery.

The *negative* may be coke, carbon, silver, platinum, or copper, and forms the *cathode*.

The *positive* is usually zinc, and its pole is the *anode*.

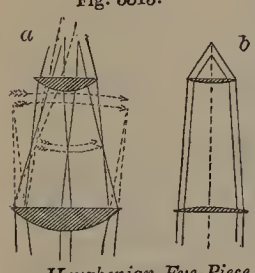
In the following order of metals the most negative is at the head of the list : —

Platinum.	Copper.
Gold.	Lead.
Antimony.	Iron.
Silver.	Tin.
Nickel.	Cadmium.
Bismuth.	Zinc.

Neg'a-tive-bath. (*Photography.*) The *bath-holder*, also known as the "bath," is a vessel used to contain the nitrate of silver solution, or bath used by photographers for making negatives. It is made most commonly of glass, but also of hard rubber and porcelain, and sometimes wood covered with asphaltum and other substances. Formerly, horizontal baths were used for large plates; these were tilted so as to throw the fluid to one end, the plate was then introduced with the collodion side upward, and the fluid allowed to return in an even wave over its surface by restoring the bath-holder to the horizontal position. Upright bath-holders are now almost always used. The best are made of glass, blown and pressed for negative plates of moderate dimensions, and constructed of pieces of thick plate-glass cemented together for larger sizes, protected externally with a strong covering of wood. The length and depth of such a vessel must suit the negative plate which is to be immersed in the upright column of solution; its width may vary from three quarters of an inch to two or even three inches. The latter, though less economical of solution in the first instance, are more so in the long run.

Neg'a-tive Eye-piece. The *Huyghenian*, or *negative eye-piece*, *a*, is the usual combination of lenses at the eye-end of a telescope or microscope. It was designed by its inventor to diminish the spherical aberration by producing the refractions at two glasses instead of one, and also to increase the field of view. It consists of two plano-convex lenses, the eye-glass and the *field*-glass, each of which presents its convex side towards the object-glass.

Fig. 3315.



a. Huyghenian Eye-Piece (Negative).

The glasses are separated from each other by about half the sum of their focal distances, the image viewed by the eye being formed between the two lenses.

b shows the *positive* eye-piece, in which the convex sides of the lenses are turned toward each other. See POSITIVE EYE-PIECE.

Neg'a-tive-well. A name for an absorbing or draining shaft, bored or dug in the ground and used to carry water through a retentive to a porous stratum in which it may escape. See ABSORBING-WELL; DRAIN-WELL.

Nei-gel'li-cloth. An Indian fabric made of *pat* or *sunn* hemp. *Crotalaria juncea.*

Ne-o-mon'o-scope. An instrument for magnifying photographs. Invented 1862.

Ne-paul'-pa'per. A strong, unsized paper made in Nepaul from the pulverized bark of the *Daphne papyraceæ*. Made many yards square.

Ne'phel-o-dom'e-ter. An instrument for ascertaining the distances of the clouds.

Ne'phel-o-rom'e-ter. An instrument for ascertaining the speed and direction of motion of the clouds.

Ne-phel'o-scope. An instrument contrived by Professor Espy to illustrate the law of the formation of aqueous vapor into clouds.

Nerve In'stru-ments. Dentists' instruments for obliterating or extracting the nerve in the root of a tooth.

Instruments for excavating and filling nerve-cavities are *burs*, *drills*, *excavators*, and *pluggers*.

Fang-fillers, *canal-pluggers*, *pulp-canal reamers*, *probes*, are also used about the nerve-canal, their purposes being indicated by their names. See BUR-DRILL.

Nerve-nee'dle. 1. (*Dental.*) A tool used for broaching out the nerve-canal to enable it to hold a dowel-pin which secures an artificial crown to the root of a natural tooth. See BROACH.

2. (*Surgical.*) An *esthesiometer* is an instrument with a pair of needles, to ascertain the tactile sensibility of different parts of the body. It has two points, adjustable as to distance, and the object is to ascertain the nearest proximity at which the points give distinct sensations. The distances vary much at different parts of the body. See ESTHESIOMETER. See also NEUROTOME.

Nest. 1. (*Gearing, etc.*) A connected series of cog-wheels or pulleys.

A set of articles of diminishing sizes, each enveloping the one next smaller in size; as a nest of crucibles, tubs, or the like.

2. *a.* A place for hens to lay. The ingenuity is scarcely appreciated by the hens, who have a modest preference for hiding upon such occasions.

The same may be said of the elaborate preparations for canaries during confinement.

b. A box for martins or sparrows on a post or in a tree.

Net. 1. A device for catching fish, birds, or other animals. It is made from a texture woven or knotted with large interstices or meshes.

Johnson defines network to be "anything reticulated or decussated with interstices between the intersections." The fabric is also used for securing or containing articles of various kinds. The *dip-net* is made in the form of a bag, the mouth of which is distended by a hoop, and is provided with a handle.

When long and narrow, having floats on one side and sinkers on the other, so as to prevent the escape of fish in shoal water, it is called a *seine*.

Nets were used by the ancients for fowling, hunting, and fishing. They were usually made of flax or hemp, and were large or small according to the purpose intended.

Nets extended on stakes and forming a corral are mentioned by the Roman writers.

A purse or tunnel net was used at the end of wing-nets.

Six kinds of fishing-nets are mentioned by Oppian.

Three of these were casting, landing, and drag nets.

The *seine* (*Sagena*) is a Greek net in name and in form.

Corks or wooden blocks, to float the upper edge of a net, and weights to depress its lower edge, are seen in Egyptian paintings; exist on an old Egyptian net now in the Berlin Museum; and are mentioned by Pliny, Ovid, and other writers.

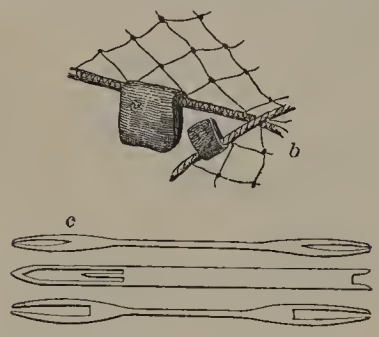
The Grecian fishing-nets also had corks and leaden weights.

Fishing was a great business in Egypt, and a painting in a tomb near the Pyramids represents a large drag-net, with floats and sinkers, in the act of being hauled by seven men, who stand on a decked boat and act under the direction of an overseer. *b* is a portion of a net with sinkers, from the Berlin Museum.

a, Fig. 3316, is an illustration from a painting in

Fig. 3316.

a



Egyptian Nets and Netting.

a tomb at Thebes, showing the mode of trapping the wild goose, which is still common on the banks of the Nile. It is similar to the common clap-net, and the rope was pulled by men secreted behind the reeds. The view shows the birds settling in the net, and a man standing behind the reeds enjoining silence. Another man stands directing the men. The reed represented is intended for the papyrus.

The ancient Egyptians made bird-nets of split reeds. Such were used in catching quails by the unfortunate outcasts on the edge of the desert forming the boundary between Egypt and Syria. This community, if it can be so called, was made up of robbers who were banished by Actisanes the Ethiopian, who was then on the throne of Egypt. Actisanes had a scruple on the subject of the death penalty, and adopted the practice of cutting off the noses of robbers and banishing them to a land where they had very hard work to obtain a living, and could disturb nobody.

c shows an ancient Egyptian netting-needle, found in Thebes, and now in Mr. Salt's collection. Their netting-needles were of wood, very like our own, split at each end, and between 10 and 11 inches in length. Others were of bronze, and the slightly elastic prongs would close except when the twine passed. Their nets were of flax twine. Pieces have come down to our day, and are preserved in the European museums.

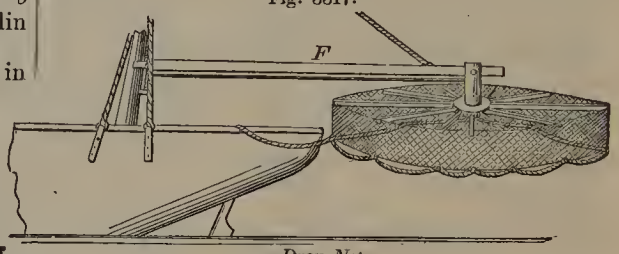
A netting-needle of wood, charged with the original thread, was found among other articles in a lady's work-basket.

In *netting*, the threads or cords are tied into hard knots at their intersections, so as to form meshes, which always continue of the same size.

The French government, in 1802, offered a reward of $10,000 to the person who would invent a machine for making knotted nets. It was adjudged to M. Buron, but the machine has not come into general use.

Fig. 3317 illustrates a device for casting a circular

Fig. 3317.

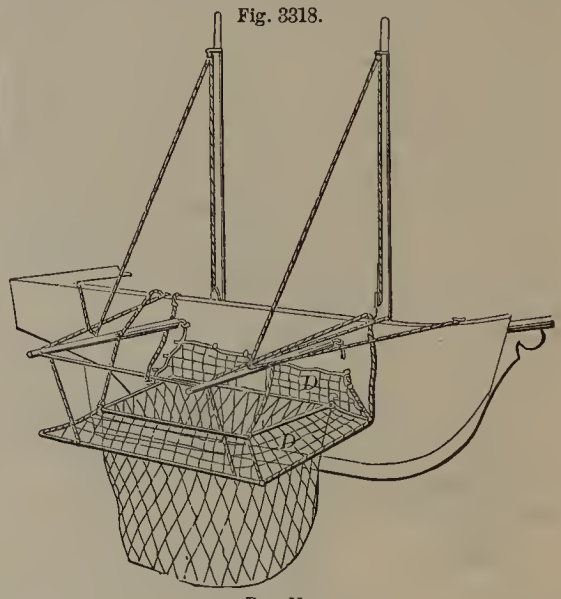


Drop-Net.

net. The net is extended upon a bolt beneath a boom *F*, and is cast by withdrawing the bolt.

In Fig. 3318, the net is suspended by booms from the vessel's side, and has a flanged edge *D*, which is

Fig. 3318.



Bag-Net.

raised when the net is "drawn," to prevent the escape of fish.

2. A kind of lace made by machinery.

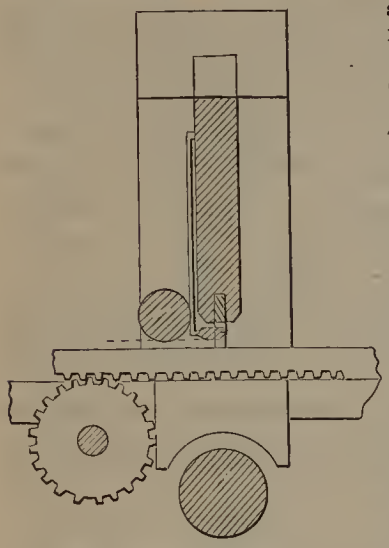
In the last century various kinds of these fabrics were made; called *whip-net*, *mail-net*, *patent-net*, *drop-net*, *spider-net*, *balloon-net*. The present varieties, deriving their name from the kind of mesh, are POINT-NET, WARP-NET, and BOBBINET (which see).

Several varieties of machine-made *net* are named from some peculiarity of fabrication.

Broad-net is woven the whole width of the machine.

Quillings are narrow strips, of which many may be made simultaneously in the breadth of the machine.

Fig. 3319.



Machine for cutting Fly-Nets.

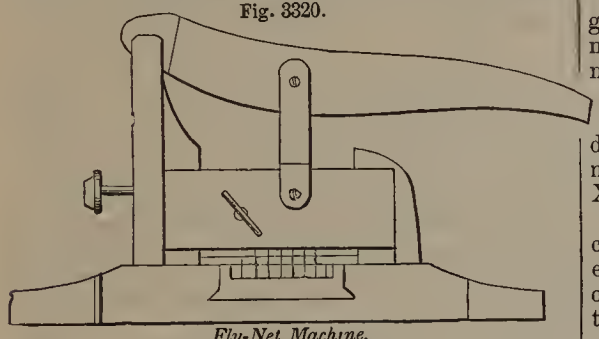
Fancy-net has a pattern worked in with gimp by the Jacquard; or by hand, called *lace-running*.

3. A covering for horses in harness, to deter or dislodge flies. Such nets are made by a succession of short slits in quincunx order, so that when the piece of leather is stretched out, the slits expand into wide openings.

In Fig. 3319, the leather is fed upon an intermittingly moving cutting-board underneath a pair of knives arranged in a guillotine sash; a spring-block steadies the leather and prevents its being drawn up when the knives rise.

In Fig. 3320 the cutters are confined in a lozenge-shaped cavity by wedge-blocks and a set-screw. The cutters have metallic blocks between them by which

Fig. 3320.



Fly-Net Machine.

the breadth of the laces is governed. The knives are depressed upon the leather by a lever, and the leather is then drawn through beneath them.

Other nets are of cord, made in the manner of fishing-nets by shuttle and mesh-stick.

A substitute for nets for horses consists of leather strings, with a few bands to keep them in place at their proper distance apart.

Net-ma'son-ry. Reticulated bond, the joints of which resemble in appearance the meshes of a net.

Net'ting. Open-work fabric for curtains or screens. See MUSQUITO-CANOPY, etc.

Net'ting-ma-chine'. Lace is said to have been first made by machinery in 1768 by Hammond, a stocking-weaver of Nottingham, England, who invented what was known as the *pin-machine*, for making single-press point-lace in imitation of Brussels ground.

The *warp-frame* for making warp-lace was introduced in 1782. The first attempt to make bobbinet by machinery was in 1799, but no successful machine was produced prior to 1809, when Heathcote patented his machine, in which, by means of bobbins, a series of diagonal weft-threads are passed around and intertwisted with the parallel threads of the warp. Many subsequent improvements were made on this machine, which has been variously modified to produce different kinds of netted fabrics, among which we may enumerate —

The bobbinet-machine.	Traverse-warp machine.
Lever-machine.	Twist-machine.
Straight-bolt machine.	Pusher-machine.
Circular-bolt machine.	

The *warp-machine*, based on the stocking-frame, was invented about 1795, and is employed in making lace, and also knit jackets, "Berlin" gloves, and similar articles. See BOBBINET-MACHINE; LACE-MAKING MACHINES.

Net'ting-nee'dle. A shuttle used in netting. One from the tombs of ancient Egypt is of the same form as used at the present day. (*c*, Fig. 3316.) See also TATTING-SHUTTLE.

Net'tings. (*Nautical.*) Nets of small rope used on board ship for various purposes, such as holding the hammocks when on deck, or for stowing sails. Also for hanging between the bulwarks and the rigging to repel boarders.

Net'tle-cloth. (*Fabric.*) A thick cotton stuff, japanned, and used as a substitute for leather.

Net'tling. (*Rope-making.*) *a.* A process whereby two ropes are joined end to end, so as to appear as one. The ends are scutched or beaten out, and spun or twisted together.

b. The tying of the yarns in pairs to prevent their becoming entangled or confused when laid upon the posts in the ropewalk.

Neu-rot'o-me. (*Surgical.*) A long, narrow scalpel, used by anatomists to dissect the nerves. *Neurectome.*

Erasistratus of the Alexandrian College of Surgeons, in the Ptolemaian period, wrote upon the nerves, and knew the distinction between those of motion and those of sensation. — *Ency. Brit.*, II. 751. Rufus of Ephesus, who was probably contemporary with Trajan, in his works on anatomy, divided the nerves into those of sensation and of motion. — *Nouvelle Biographie Générale*, Tome XLII. p. 882.

Nevertheless, Sir Charles Bell and Mr. Mayo are credited by Whewell (History of the Inductive Sciences, III. 425) with the discovery "that the two offices of conducting the motive impressions from the central seat of the will to the muscles, and of propagating sensations from the surface of the body and the external organs of sense to the sentient mind, reside in two distinct portions of the nervous substance."

New'el. 1. (*Carpentry.*) The post at the head or foot of a stairs, supporting the hand-rail.

The center-post of a winding stairs is a *solid newel*.

Winding stairs around a central well are said to have an *open newel* or *hollow newel*.

2. (*Shipwrighting.*) An upright piece of timber to receive the tenons of the rails that lead from the breastwork of the gangway.

New-sand. (*Founding.*) Facing-sand.

News'pa-per. The newspaper, like many other useful inventions, seems to have originated in China. The Pekin "Gazette," the oldest daily in the world, was first issued about A. D. 1350. This is still in existence, and is an official journal, containing such information as the government chooses to make known. It is composed of three parts: 1. The court journal, or "copy of the door of the palace," which announces day by day the list of functionaries on duty, the actions of the emperor, the presentations, visits, departures, etc.; 2. The imperial decrees; 3. The reports of the great officers of the crown. It forms a pamphlet of 20 to 40 pages of coarse paper, printed from wooden types on one side only, and having a paper cover. It has a cir-

culation of many thousand copies, which are distributed to subscribers in the city or sent in packages to the provinces. The subscription price is about $6 per year, but many copies are hired for the day and returned in the evening.

In the last century the Jesuits introduced copper types, rendering the paper much neater in appearance, as well as saving labor; but in 1820 the wooden type previously used was again brought into requisition.

Its contents are often of a curious nature. Recently a petition appeared, praying the emperor to confer a title of honor upon a female spirit who had performed various services, such as filling with water the channel of a river in a dry season, and destroying or dispersing bands of rebels. The rage for obtaining office, and the practice of stealing after obtaining it, indicate that China is not, in some respects, behind countries claiming a higher degree of civilization. The oldest applicant recently gazetted, aged 102 years, passed his civil-service examination with eclat, and numerous others are over 90, none of the juniors owning up to less than 70 years.

A general is denounced for conducting but 3,000 men against the rebels instead of 5,000, the number for which he drew pay, pocketing the difference.

The origin of newspapers in Europe may be traced to the "Notizie Scritte" of Venice, written sheets, containing news items, etc., which still maintained their circulation at a comparatively recent period, owing to the restrictions placed on the press in Italy.

To Germany and England are due the first printed periodical publications.

The first English newspaper authentically known was entitled "News out of Holland"; it was established in 1619, and published at irregular intervals. This was succeeded by "Certaine News of the present Week," the first number of which was issued May 23, 1622, and was followed within the next five years by a number of other regularly published journals.

During the period of the Commonwealth and the Restoration their number multiplied, but none appear to have been published oftener than once a week until about the reign of Queen Anne, when the demand for news from the Duke of Marlborough's army led to their being issued tri-weekly.

The first London daily was the "Courant," published by Samuel Buckley in 1703. The first established newspaper in England, outside of London, is believed to have been the "Norwich Postman," 1706.

The first actually published in Scotland was at Edinburgh in 1654.

The "Dublin News-letter," the earliest Irish paper, was established in 1685.

In the United States a newspaper was attempted as early as 1690. The first number was dated September 25 of that year, but its farther issue was prevented by the colonial government, it being "published contrary to law, and containing reflections of a very high nature." In 1704 the "Boston News-letter," published "by authority," was established by John Campbell, and in 1719 the "Boston Gazette," also "by authority." To these succeeded the "New England Courant," by James Franklin, a brother of the Doctor. Andrew Bradford founded a paper at Philadelphia in 1719, and his father, William Bradford, issued the first newspaper published in New York, the "New York Gazette," in 1725. From this period they multiplied rapidly in the Colonies.

The common name "Gazette" is derived from the name of a Venetian coin, worth about a cent and a half, and which was the price of the Venetian newspaper first published.

The "Maryland Gazette" was established in 1727 or 1728; the "Virginia Gazette," 1736; the "Rhode Island Gazette," 1732; "South Carolina Gazette," 1731 or 1732; "Georgia Gazette," 1763.

The first paper in New Hampshire was published in 1756, but in the adjacent State of Vermont none existed prior to 1781.

After the Revolution, the history of newspaper progress becomes identical with that of the nation, the printing-press keeping closely in the van of Anglo-American civilization.

The honor of publishing the first paper west of the Alleghanies is claimed for John Scull of Pittsburgh, who, it is stated, founded the "Pittsburgh Gazette" in 1783.

The first north of the Ohio River, being the third or fourth west of the Alleghanies, is said to have been the "Centinel of the Northwest Territory," by William Maxwell, 1793.

According to De Saint Foix, the earliest French newspaper, called the "Gazette de France," was established by Renaudot, a physician, who obtained a royal grant of the exclusive privilege of publishing the same for himself and family. He had previously been in the habit of collecting information and circulating news-sheets among his patients.

The first German newspaper was established at Frankfort in 1615. An illustrated war gazette, the "Niewtijdinge," published in the Low Countries, had, however, preceded this by ten years.

In Sweden, a newspaper was published as early as 1643, entitled the "Ordinarie Post Tidende."

Journalism in Spain and Italy, owing to the lack of general education, and restrictions on the liberty of the press, has, until recently at least, remained in rather a backward state. In the former country newspapers issued at irregular intervals were published during the seventeenth century, but those appearing regularly do not seem to have been introduced until the next; and in Italy, though never entirely suppressed, their continuance under the depressing influences by which they were surrounded, produced no one of extensive circulation or influence.

The same may be said of Russia, where the periodical press was first introduced under the auspices of Peter the Great; and of Turkey, whose first newspaper only dates back to 1795.

Fig 3321.

Newspaper-File.

News'pa-per Ad-dress'ing-ma-chine'. A machine for printing addresses on newspaper wrappers or attaching printed labels to newspapers or their wrappers. See ADDRESSING-MACHINE.

News'pa-per-clamp. A means for fastening newspapers to a back, in temporary cover, or on a desk, so as to preserve them in a convenient condition for reference. See PAPER-FILE.

News'pa-per-file. A clamp to hold newspapers by the folded edge in convenient condition for reference and preservation. The two rods spring apart, but are retained by a hook. See PAPER-CLAMP.

News'pa-per Fold'ing-ma-chine'. A machine for folding newspapers for mailing. See FOLDING-MACHINE.

New-to'ni-an Tel'e-scope. A form of the reflecting-telescope, in which the rays are reflected from the surface of the object-mirror and intercepted by a small oval mirror placed in the axis of the tube at an an-

gle of 45°. The image which would have been formed in the axis is thereby deflected and is viewed by an eye-piece attached at a right angle to the side of the tube. See REFLECTING-TELESCOPE.

The small mirror is fixed on the end of a slender arm connected to a slide, by which it is made to approach or recede from the large speculum, as may be required. See TELESCOPE.

Nib. 1. (*Husbandry.*) The handle of a scythe-snath. It has a ring slipping on the snath and tightened by a bolt or wedge.

2. (*Locksmithing.*) A separate adjustable limb of a permutation key.

3. *a.* One of the points of a pen. Pens have usually two nibs, but Perry's have three.

b. A small pen adapted to be placed in a holder for use. The usual form of steel pens. Quill nibs are also made and similarly held for writing. Such *quill nibs* have no *barrel*, as the cylinder of the quill is called. Steel pens having a cylindrical shape to hold on to a round stick are called *barrel-pens*.

4. The point of a crow-bar.

Nib'bling. (*Lens-making.*) Reducing a blank of glass to roundness preparatory to grinding it for a lens. The operation is performed by a pair of flat pliers of soft iron, called *shanks*, which crumble away the edge of the glass and do not slip, as tools with steel jaws would be apt to do.

Niche. (*Architecture.*) A hollow or alcove in the face of a wall for a statue, clock, etc.

Nick. 1. (*Printing.*) The notch on the bottom edge of the shank of a type, forming a guide to the compositor in *setting*.

2. The slit in the head of a screw at which the screw-driver is applied.

3. A notch or incision at a measured distance on an object. A cut to form a starting-point for a kerf.

Nick'el. Equivalent, 29.6; symbol, Ni.; specific gravity, 8.279, which is increased by hammering to 8.82. Fuzes at about 2,800° F. A brilliant, silver-white, ductile metal discovered by Cronstedt in a mineral derisively termed by the miners *nick* or *copper-nick*, on account of its resembling copper ore in appearance, but disappointing them by yielding no copper.

Its ores are found in many parts of the world; in America they have been discovered in Massachusetts, New York, New Jersey, Pennsylvania, Connecticut, Tennessee, Missouri, and Canada. The principal are smaltine or smaltite, from which smalts, zaffre, and cobalt are also extracted; the residue after calcination, called *speiss*, yields some 50 per cent of nickel. Copper nickel contains about 45 per cent of nickel and a large amount of arsenic.

Millerite, a sulphide of nickel, containing 65 per cent of nickel and 35 per cent of sulphur, is found in New York and Pennsylvania, and is largely mined in the latter State.

Pyrrhotite, a species of sulphide of nickel, though containing but a small percentage, from 3 to 6 per cent of the pure metal, is so abundant and widely distributed as to constitute a principal source of supply.

The metal is also found in meteorites in proportions varying from 1 to 20 per cent.

Nickel acts upon the magnet, but more feebly than iron; when heated to 350° F. it loses this power.

Its chief use is in alloys and for plating. It enters into the composition of albata, packfong, or tutenag, German-silver, and numerous other alloys having specific names conferred by their compounders.

The common varieties have 3 to 4 parts nickel; 20 copper; and 16 zinc.

The finer varieties, 5 to 6 parts nickel; 20 copper; 8 to 10 zinc. (See ALLOY.) The pure metal is used for plating, and some of its alloys, containing a large proportion of the metal, for small coin.

In the ordinary process of reducing nickel, the ore is coarsely ground and roasted, mixed with ground fluor-spar, and treated with three times its weight of sulphuric acid, being at the same time gently heated and agitated in a leaden vat. Any hard mass resulting is broken into small pieces, calcined in a reverberatory furnace, and dissolved in hot water, extricating the sulphate of lime. The solid residuum contains several metals, which are separated by first dissolving it in a mixture of nitric and sulphuric acids, and allowing it to stand until crystallization ensues; the crystals are now dissolved in water, and the iron precipitated by carbonate of soda; copper is precipitated by a current of sulphureted hydrogen gas, and cobalt is separated by chlorine, which forms a chloride of nickel, leaving the cobalt free. The chloride is then treated with bicarbonate of soda in solution, evaporated and dried and calcined. The carbonate of nickel thus formed is mixed with charcoal and fluor-spar or other flux, and exposed to intense heat, which produces the metal in a state sufficiently pure for ordinary purposes. It may be obtained chemically pure by the application of a jet of hydrogen gas to the carbonate in process of reduction.

Nick'el-plat'ing. The surfacing of metals with nickel to render them less liable to oxidation by heat or moisture. The operation is effected by a heated solution or in the electro-bath. It has been applied to many articles, such as gas-tips, barrels, and other metallic portions of fire-arms, sieves exposed to water, culinary vessels, type-facing, buckles, and other hardware, buttons, etc., etc.

Kirwan, in 1782, precipitated nickel from its solutions. He says: "Zinc precipitates nickel from the marine acid. Iron clearly precipitates nickel from the nitrous acid." (*Phil. Trans.*, Vol. LXXVII. pp. 73–84.)

Golding Bird in 1837 describes the electro deposition of nickel and other metals by the action of long-continued currents of low tension. (*Phil. Trans*, Vol. CXXVII. pp. 37–45.)

Shore, 1840, used a solution of nitrate of nickel in one compartment of battery, and weak sulphuric acid and zinc in the other, for deposition of nickel.

An alloy of nickel and tin made by melting under borax and glass was used for coating iron plates by Richardson and Braithwaite, 1840. The alloy was applied melted, as in tinning iron.

Alfred Smee made an electro deposition of nickel in 1841. (*Smee's Elements of Electro-Metallurgy.*)

Böttger, in the "Journal für Praktische Chemie," Vol XXX. p. 267, 1843, says that among all the salts of nickel the ammonio sulphate of protoxyde of nickel is especially useful in plating brass and copper, and is much superior to cyanide nickel of potash, as recommended by Ruolz. He proceeds at some length to state the effectiveness of the battery in producing a deposit of nickel on copper in half an hour, which would deflect the needle, and preserve the lower metal from the effect of nitric acid more perfectly than a coating of gold deposited in the same time.

Parkes, 1845, melted an alloy of nickel with a flux for coating metal plates.

Junot, 1852, alloyed silicum, titanium, tungsten, etc., with nickel for electro deposition.

Thomas, 1854, used ferro-cyanide of potassium and nitro-muriatic acid to obtain a nickel solution for the battery. In 1855 he used the same, with carbonate of ammonia and oxide of alumina.

Cheatley, 1855, deposited alloys of nickel by a battery (British patent 1543, of 1855).

An alloy of nickel was applied to iron plates by friction and heat by Barron in 1856.

Shepard, 1858, deposited an alloy of silver and nickel. The solution is made by adding carbonate of ammonia to a solution of nitrate of silver, then a similar solution of carbonate of nickel in carbonate of ammonia. An anode of one part silver and two parts nickel is used. Cyanide of potassium may be used in the battery.

Adams, United States patent No. 57,271, 1866, coats gas-tips with nickel. Same, 1869, uses solution of sulphate of nickel in solution of sulphite or bisulphite of ammonia. Same, 1869, effects electro deposition by a solution of double sulphate of nickel and ammonia, free from acid or alkaline reaction. He

uses a nickel and iron anode. His patent, No. 102,748, claims the use of a nickel anode combined with carbon. Patent of 1871 uses a heated battery.

Dr Adam's process consists in the depositiou by electro-magnetic agency of metallic uickel from either of three solutious: —

1, one formed of the double sulphate of nickel and alumina; 2, of the double sulphate of nickel and potash; 3, of the double sulphate of nickel and magnesia.

These solutions are preferably used at a temperature above 100° Fah., and must be so prepared and used as to be free from any acid or alkaline reaction. For this purpose care must be takeu to avoid the use of too high a battery power or the introductiou of any foreign matter into the solution.

In Nagel's process, two parts of sulphide of the protoxide of nickel and one of ammonia are combined to form a double salt: this is dissolved in water, and a solution of ammonia added. The deposition is effected by a battery having a platinum positive pole, the solution being heated to about 100° Fah. Coating with cobalt is effected in an analogous way.

It has been proposed to color the nickel during deposition from a similar solution by usiug two anodes, one of iron, the other of nickel. If the coating indicates an excess of either metal, the corresponding anode is raised partially or wholly from the solution until the proper combination is produced.

Nickeling. Professor Sharples says: "The double sulphate of nickel and ammonium, which is the salt that is generally used, may now be had in commerce almost pure. Cast-nickel plates for anodes may also be obtained. The anodes should considerably exceed in size the articles to be covered with nickel. Any common form of battery may be used. Three Daniell's or Smee's cells, or two Bunsen's, connected for intensity, will be found to be sufficient. The battery power must not be too strong, or the deposited nickel will be black. A strong solution of the sulphate is made and placed in any suitable vessel: a glazed stoneware pot answers very well, if the articles to be covered are small. Across the top of this are placed two heavy copper wires, to one of which the articles to be covered are suspended, to the other the anode. The wire leading from the zinc of the battery must then be connected with the wire from which the articles are suspended, the other battery wire being connected with the anode.

"In order to prepare the articles for coating, they must be well cleaned by first scrubbing them with caustic soda or potash, to remove any grease, and then dipping them for an instant in *aqua regia* and afterward washing thoroughly with water, taking care that the hand does not come in contact with any part of them. This is accomplished by fastening a flexible copper wire around them, and handling them by means of it The wire serves afterward to suspend them in the bath.

"If the articles are made of iron or steel, they must be first covered with a thin coat of copper. This is best done by the cyanide bath, which is prepared by dissolving precipitated oxide of copper in cyanide of potassium. A copper plate is used as an anode. After they are removed from the copper bath, they must be washed quickly with water and placed in the nickel bath; if allowed to dry or become tarnished, the nickel will not adhere.

"Great care must be used through the whole process to keep all grease, dust, or other dirt from the articles to be covered, or else the result will be unsatisfactory. The whole process is one of the most difficult that is used in the arts, it being far easier to gild, plate, or copper an article than to nickel it; but if due care be taken, the results will amply pay for the trouble." — *Boston Journal of Chemistry.*

Martin and Delaunotte propose to use nickel salts with organic acids instead of those generally employed. The bath is prepared by dissolving 1,250 grams citric acid, 500 grams sal-ammoniac (or sulphate of ammonia), and 500 grams nitrate of ammonia in 15 liters of water. The solution is heated to 80° C., and gradually saturated with freshly precipitated hydrated protoxide of nickel. The heat is then removed, 2¼ liters of ammonia added, and water enough to make 25 liters, so that each liter of the bath contains about 50 grams of nickel. When cold, 500 grams carbonate of ammonia is added, the sediment allowed to settle, and filtered. The bath has a blue-black color, stands at 11° B., and is used at a temperature of about 50° C. Caustic potash or soda gives a thicker deposit.

In Professor Stolba's process, a quantity of concentrated chloride of zinc solution is placed in a clean metallic vessel, and to this is added an equal volume of water. This is heated to boiling, and hydrochloric acid is added drop by drop until the precipitate which has formed on adding water has disappeared. A small quantity of zinc powder is now added, which produces a zinc coating on the metal as far as the liquid extends. Enough of the nickel salt (chloride or sulphate) is then added to color the liquid distinctly green; the objects to be plated are placed in it, together with some zinc clippings, and the liquid is brought to boiling. The nickel is precipitated in the course of fifteen minutes, and the objects will be found to be completely coated. The coating varies in luster with the character of the metallic surface; where this is polished, the plating is likewise lustrous, and *vice versa*

The following United States patents may be consulted: —

No. 57,271, Adams, 1866
No. 82,877, Remington, 1868.
No. 87,385, Winchester, 1869.
No. 90,332, Adams, 1869.
No. 90,476, Adams, 1869.
No. 92,337, Moore, 1869.
No. 93,157, Adams, 1869
No. 95,053, Smith, 1869.
No. 98,006, Adams, 1869.
No. 98,354, Crooke, 1869.
No. 100,038, Howard, 1870.
No. 100,961, Adams, 1870.
No. 102,748, Adams, 1870.
No. 103,201, Kuhns, 1870.
No. 106,823, Howard, 1870
No. 109,475, Watrous, 1870.
No. 113,612, Adams, 1871
No. 114,191, Parmalee, 1871.
No. 116,579, Farmer, 1871.
No. 116,658, Adams, 1871.

Nick'er. The cutting-lip at the circumference of a center-bit, which cuts in the wood the circle of the hole to be bored. The lip which removes the wood is the *router*.

Nick'ing-bud'dle. (*Metallurgy.*) A form of buddle used in washing lead ore.

Nick'ing-file. A thin file for making nicks in heads of screws.

Nick'ing-trunk. (*Metallurgy.*) A tub in which metalliferous slimes are washed. At the upper end is a trough which discharges a gentle sheet of water over a *nicking-board*, which divides the water into rills and gradually washes off the slimes, settling them on the flat surface of the table in the order of their respective gravities.

Nidged. Nigged; as ashlar.

Ni-el'lo. A method of engraving on gold or silver, which consists in running in along the engraved lines, while hot, a composition called *niello*, composed of silver and other metals more fusible than silver, as lead, copper, etc. This compound is of a black color. This ancient art was revived by the Italians about four centuries since, and in the practice of taking proofs of the work the art of copperplate printing was discovered. The suggestion seems first to have been improved by Tomasso Finiguerra.

The art is still practiced as a mode of ornamenting metal ware, but its principal use is in door-plates, plates for shop fronts, etc., in which the brass or zinc plates are engraved and the depressions filled with wax.

Nig'ged Ash'lar. (*Masonry.*) A building stone roughly dressed with a pointed hammer.

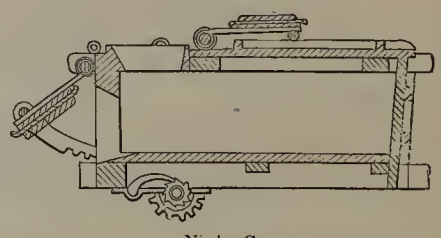
The tool is called a *scabbling-hammer*, and the operation *nigging* or *nidying*.

Nig'ger. (*Steam-engine.*) A steam-engine employed in hoisting; especially on shipboard and on the Western and Southern rivers.

Night-bolt. A spring-bolt in a lock, opened by a knob from the inside of the door, by a key from the outside, but capable of being fastened so as to be immovable from either side.

Night-cart. One employed in carrying away the contents of cesspools and privies. The example is the box of a cart with tightly fitting shutters at the

Fig. 3322.



Night-Cart.

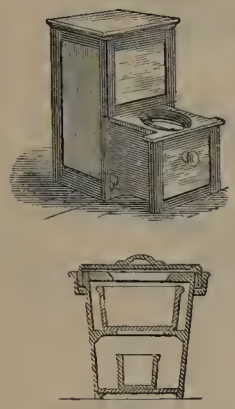
rear part of the box. The upper shutter is held down by levers and holding chains. The discharge-shutter is pivoted at the upper edge and is operated by segmental racks and pinions turned by a hand-lever. The joints are packed to prevent leakage and confine the odor.

Some forms of carts are loaded by means of pipes and an air-exhaust. Barrels, in some cases, are substituted for cart-boxes, and are filled by means

of the pressure induced by the condensation of steam which has previously driven the air from the barrels.

Night-chair. A COMMODE or EARTH-CLOSET (which see) for the sick-room. It is usually made like a chair with a pan in the seat and means for perfectly inclosing the contents, so as to prevent the emission of odor. A common form has a lid whose edge dips into a circular trough around the seat.

Fig. 3323.



Disinfecting Night-Chair.

In the example, the covered pail contains a pan for the feces and one for the disinfectant which deodorizes the mephitic vapors.

Night-latch. A form of door-lock in which the spring-latch may be opened by a key from the outside, or may be fastened shut so as to be immovable from the exterior of the door.

Night-light. A short thick candle with a small wick so proportioned as to burn in a little puddle oil of melted tallow without burning the paper envelope of the cylinder of tallow.

When made of spermaceti or stearine it has no envelope, and the wick is made to bend over in burning, being totally consumed so as not to drop ashes in the tallow. A *mortar*.

Nill. Scales of hot iron from the forge.

Ni-lom'e-ter. An instrument similar to a tide-gage for measuring the rise of the Nile during its periodical floods. One is situated on the island of Er-Ródah, and consists of a graduated pillar, upon which the hight of the water is read off. The pillar stands in a well which communicates with the river.

The rise of the Nile has always been a subject of great anxiety in Egypt, as upon the periodical saturation of the ground and the coating of soil which is left upon it, the success of the year's husbandry depends.

From the earliest historic period nilometers have been placed in prominent positions in Egypt, to enable the officers to watch the rise, which was proclaimed by criers.

Asama (a governor of Egypt under the Khalif Suleiman) erected the nilometer in the vicinity of what was afterward Grand Cairo, year Hegira 97.

"Citizen Langles has been employed in examining the various nilometers from Alouyah, above the cataracts, to Lower Egypt. He finds 15 between the isle of Elephantina and the mouth of the Nile." — *Nat. Institute of France*, 1800.

The rise seems to have been less in former times than now. In the days of Mœris it is said that 8 cubits were sufficient; 15 or 16 were required in the time of Herodotus, 456 B. C. At the present day 18 cubits is considered the lowest inundation at Cairo.

Hear the "Father of History": —

"One fact which I learnt of the priests is to me a strong evidence of the origin of the country. They said to me that, when Mœris was king, the Nile overflowed all Egypt below Memphis, as soon as it rose so little as 8 cubits. Now Mœris had not been dead 900 years at the time when I heard this of the priests; yet at the present day, unless the river rise 15 or 16 cubits, it does not overflow the lands. It seems to me, therefore, if the land goes on rising and growing at this rate, the Egyptians who dwell upon Lake Mœris, in the Delta (as it is called), and elsewhere, will one day, by the stoppage of the inundations, suffer permanently the fate which they told me they expected would some day or other befall the Greeks. On hearing that the whole land of Greece is watered by rain from heaven, and not, like their own, inundated by rivers, they observed, 'Some day the Greeks will be disappointed of their grand hope, and then they will be wretchedly hungry,' as much as to say, 'If God shall some day see fit not to grant the Greeks rain, but shall afflict them with a long drought, the Greeks will be swept away by a famine, since they have nothing to rely on but rain from Jove, and have no other resource for water.'" — HERODOTUS, II. 13.

Wilkinson, very unreasonably as it would appear, combats the idea of Herodotus, and states that the rise at Memphis has always averaged about 16 cubits; say 40 at Assouan, 36 at Thebes, 25 at Cairo, and 4 at the mouth of the river. See Wilkinson's "Herodotus," Am. ed., 2d Vol., pp. 252 – 254.

In the time of Pliny 12 cubits were a famine, 13 a scarcity, 15 was safety, 16 plenty. At the present day, 18 cubits is the lowest, and at this hight the canals are cut and distribution commences; 19 cubits are tolerable, 20 adequate, 21 excellent, 22 abundant, and 24 ruinous, as invading the houses and stores of the country.

The nilometer at Cairo has been erected for many centuries, but it is not nearly so ancient as that at Elephanta, which consists of a staircase between two walls descending to the Nile. One wall has engraved upon it a series of marks representing the hight to which the water has risen on certain occasions. The cubits here are divided into 14ths, or double digits, and measure 1 foot 8.625 inches. This nilometer was described by Strabo, 54 B. C.

The nilometer at Memphis was transferred by Constantine to a church in the vicinity of the Serapeum of Alexandria; Julian sent it back to the building at Memphis, where it remained till its destruction by Theodosius.

At the present day the rise is watched for with anxiety, and proclaimed by 4 criers.

The object of the nilometers formerly was to settle the amount of taxation to be imposed upon the country. It may still be the basis of the impost of taxes in that overridden country. *Eminent domain* there includes the land, the poor fellahs upon it, and the water.

The effect of the rise is a gradual elevation of the soil of the country, amounting to about 6 inches in a century at Elephanta. The land at that point has been raised 9 feet in 1,700 years; at Thebes about 7 feet, and less toward the Delta, where the periodical rise is about 4 feet. Many of the sites of antiquity are buried beneath the surface, and some of the ancient buildings yet remaining, which were originally placed outside of the cultivatable land, are now surrounded by arable tracts.

The cause of the inundation is the water that falls in Abyssinia in the rainy season. Homer and the Koran are right in ascribing it to water sent by God from heaven.

Calisthenes, the pupil of Aristotle, and afterward Agatharcides of Cnidus (2d century B. C.), and Strabo, ascribed it to the same true source, — the rainy season in Ethiopia.

The rainy season in Ethiopia commences (Kenrick) about the spring equinox and prevails till after the summer solstice. The Upper Nile of course first

feels the rise; at Khartoom early in May; at the Cataracts about the first of June. It becomes visible in Egypt about the middle of June. About the middle of August half the rise is attained, and the dikes are then cut; the rise occupies about 100 days, as stated by Herodotus. The maximum is about the 25th of September. After remaining stationary for 12 or 14 days, it commences sinking, and is within its banks again about the 10th of November. Its minimum stage is about the middle of May; the depth at Cairo is then about 6 feet.

The increase of the Nile during inundation is 9-fold its quantity during an ordinary stage. The rate of flow during inundation is 6 feet per second at E' Sinout, about the middle of Egypt; during low water the rate of flow is from $1\frac{1}{3}$ to 2 knots per hour. The immediate banks of the river are seldom covered, and serve as highways. The general breadth of the river is about $\frac{1}{3}$ of a mile. It receives no tributaries after leaving Abyssinia, and consequently does not increase in size.

A *low* Nile causes famine. We read of such in Genesis; one A. D. 1200, cited in Abdollatiph's History of Egypt; two in 1784–85, mentioned by Volney. The latter was very destructive, and was caused by light rainfall in Ethiopia. Multitudes sought food in Palestine and Syria.

Nine-pin Block. (*Nautical.*) A block whose shell is spindle-shaped, resembling one of a set of nine-pins. Its ends are swiveled in an upper and lower bar, so that the plane of the sheave may be presented in any direction. It acts as a fair-leader under the cross-pieces of the bitts.

Fig. 3324.

Nine-Pin Block.

Ni-o'bi-um. Symbol, *Nb*. A rare metal, not specially useful in the arts. Once called *columbium*.

Nip. (*Mining.*) The gradual approach of the strata above and below a seam and terminating it.

Nip'per. (*Nautical.*) Strong scizings for binding the messenger to the cable, to form slings, etc. They are made from clean unchafed yarns drawn from unlaid rope.

Nip'per-gage. (*Printing.*) A ledge adjustable on the tongue of the feed-board of a power-press. Used in keeping the required margin uniform.

Nip'pers. 1. A grasping tool with cutting jaws. *b c d e f* show several forms with various presentations of the blades.

2. (*Dentistry, etc.*) The mechanical forceps or nippers used by dentists are for operating on the plates. The following cuts of the operative portions will explain their construction.

g, nipper for cutting off chambers and cutting off backings from plates.

h, nipper for cutting out plates.

i, punch for rivet-holes.

j, plate-bender for upper plate.

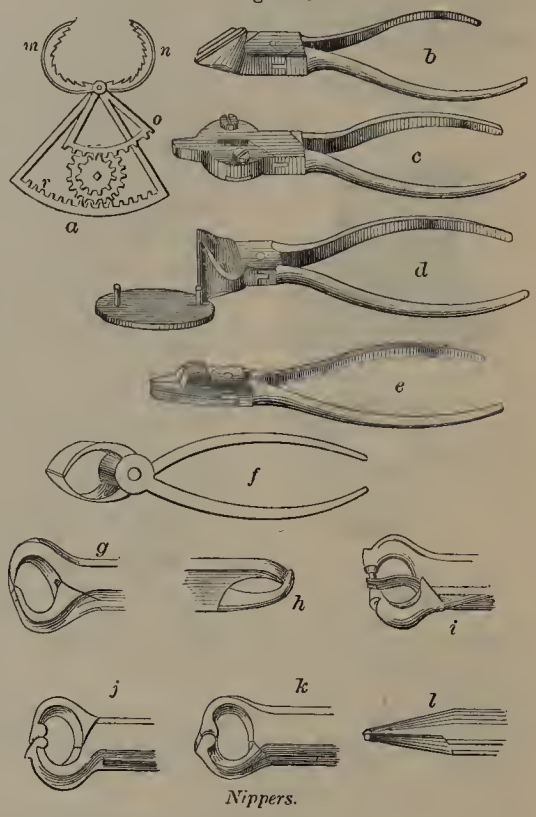
k, plate-bender for lower plate.

l, clasp-bender.

3. (*Hydraulic Engineering.*) Nippers (*a*) for cutting off the heads of piles under water consist of two serrated jaws *m n*, one attached to the small sector *o*, and the other to the large sector *r*. On each sector is a cogged arc engaged by two pinions on an axis which is perpendicular to the plane of oscillation of the nippers. A rotary reciprocation is imparted to the nippers, which cuts off the pile, the jaws being gradually approached by rotation of the axis and pinions as the teeth bury themselves in the wood.

4. (*Printing.*) The clasps which catch the sheet and conduct it to the form.

Fig. 3325

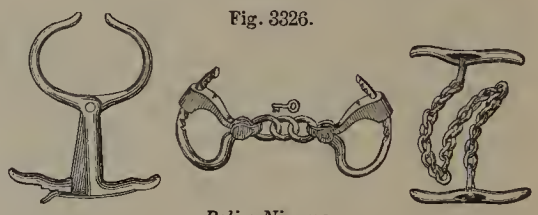


Nippers.

5. (*Wire-drawing.*) The tool for pulling the wire through the plate.

6. Hand-cuffs or foot-shackles for prisoners.

Fig. 3326.



Police Nippers.

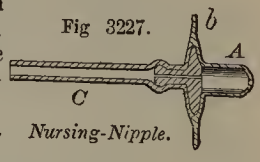
Nip'ple. 1. (*Machinery.*) A small, rounded, perforated protuberance; as the nipple of a gun on which the percussion-cap is placed. A *teat*.

Solid, it is a stud, boss, knob, button.

2. The teat of a nursing-bottle.

Nip'ple, Ar'ti-fi'cial. 1. A concave shield of hard wood, ivory, or india-rubber, fitted to the breast. Inserted in its center is a cup to cover the nipple, made of india-rubber or prepared cow's teat. It is used by women with sore breasts as a protection, to prevent babies biting the nipple while sucking. A *nipple-shield*.

Fig 3227.



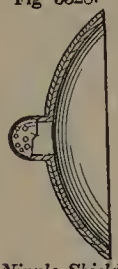
Nursing-Nipple.

2. A nipple attached to a milk-bottle for the infant. The nipple *A*, shown in the example, has a stop-flange *b* to keep it from passing too far into the infant's mouth. A perforated button is a means of attaching the india-rubber tube *C* to the nipple.

Nip'ple-seat. (*Fire-arm.*) The *hump* on the side of a barrel on which the nipple is screwed and through which the fire is carried to the charge.

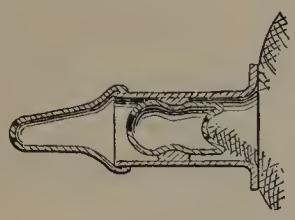
Nip'ple-shield. One for the protection of the mother's nipple, that it may not be bitten by the nursing infant. It has a cap of horn or vulcanite,

Fig 3328.



Nipple-Shield.

Fig 3329.



Artificial Nipple and Shield.

and the nipple-shield is a fine, elastic, perforated membrane of india-rubber.

Or, as in Fig. 3329, the interior adjustable sliding screen limits the elongation of the nipple when suction is applied.

Nip'ple-wrench. (*Fire-arm.*) The spanner with sides which fit the square of the nipple, and which is used for screwing it to and unscrewing it from the barrel.

Ni'ril. The vibration or chattering of a turning-tool not accurately centered or fitted.

Ni'tric-ac'id Fur'nace. The nitric-acid furnace consists of a number of parallel horizontal cast-iron retorts, arranged in pairs, which connect by luted tubes with a series of receivers and two-necked Woulfe-bottles, wherein the fumes are condensed and collected.

The retorts are charged with nitrate of potash or soda and sulphuric acid. The resulting sulphate is scraped out after removing the end of the retort.

In the *gallery-furnace* the retorts are sunk in sand-pots whose lower surfaces are exposed to the heat of the furnace fire.

Ni-trine'. An explosive compound patented by Nobel, August 14, 1866; formed of glycerine, sulphuric and nitric acids, free of hypo-nitric acid.

Ni'tro-gly'cerine. *Nitroleum, glonoin,* or *blasting-oil.* Discovered by Sobreso, professor of applied chemistry at Turin, in 1847, and introduced into this country in 1864 by Nobel, a Swedish engineer.

An oily liquid of a specific gravity of 1.6, having a sweet aromatic taste, colorless when pure, but, as manufactured, it is usually light yellow. If heated up to 100°, no change takes place; heated gradually to 193°, it is decomposed, losing its explosive power. When not under pressure it burns quietly. Heating when confined may create a partial decomposition, and an explosion from the pressure thus generated. An electric spark will pass through it without causing explosion unless a series of sparks are passed through it until decomposition is caused and heat generated. Fire alone ordinarily will not explode it. Jarring nitro-glycerine, even when at a temperature of 50° C., will not explode it. Explosions occur: 1. When confined and heated to 180° C.; 2. If struck so as to create heat and pressure; percussion causes it to explode with difficulty when frozen, which takes place at 8°, but striking it when in that state with a sharp hard substance, as a pick, will then easily explode it. — *Journal of Applied Chemistry.*

It is prepared by successively adding small quantities of glycerine to a mixture of nitric and sulphuric acids and pouring the compound into water, when the nitroleum, which is insoluble in and heavier than water, falls to the bottom of the vessel.

The acids used should be of the purest quality, and great care taken to avoid the introduction of foreign matters; otherwise slow decomposition, which may finally result in spontaneous explosion, occurs. For this reason it is better to have it made on the spot and used soon after making.

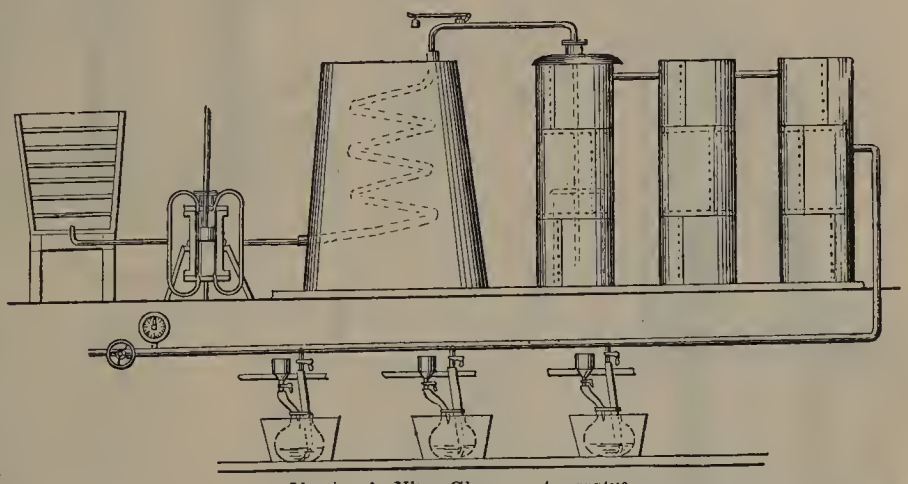
It may be purified by dissolving it, very gradually and at a temperature not exceeding 50° F., in sulphuric acid, and separating the nitroleum by the gradual addition of nitric acid, and then pouring, in a fine stream, into pure cold water from which the air has been expelled by boiling; in the preparation the temperature of 50° should in no case be exceeded.

In Mowbray's process, a current of cold, dry air is passed through the vessels in which the compound is made, for carrying off the hypo-nitrous acid and to cool and agitate the mixture.

The vessels are lined with glass.

This substance has been extensively used for blasting purposes; in the Mt. Cenis and Hoosac tunnels, the operations at Blossom Rock, harbor of San Francisco, in the improvements of the East River, New York, and elsewhere. (See BLASTING; TUNNEL.) Developing about ten times the explosive power of gunpowder, it requires far less drilling and operates so as to lift the rock from its bed without shattering it to such an extent. The number of fatal explosions resulting from it have been an obstacle to its more general use, but these are claimed to have resulted generally from improper manufacture, exposure to too great heat in transportation, or carelessness in handling.

Fig. 3330.



Mowbray's Nitro-Glycerine Apparatus.

Among the most prominent accidents occurring from these sources were the explosions at Aspinwall and in the office of Wells, Fargo, & Co. at San Francisco, by the former of which forty-five and by the latter six lives were destroyed. In the case of the Aspinwall disaster the nitroleum had been shipped from Hamburg, where the temperature was 55° or 60° to a tropical climate where the temperature in the hold of the steamer was probably more than double this. It was inclosed in cork-stopped vessels, packed in cases with sawdust. The explosion has been attributed to the disengagement of gas, which,

by the corrosion of the corks, escaped into the surrounding sawdust, forming a new and easily ignited compound, which, becoming mixed with the undecomposed uitroleum which escaped, was easily exploded at sueh a high temperature by the rough handling to which it was subjeeted by the stevedores. The sheriff, surveyor, and four other persons were killed by an explosion at Neweastle on Tyne, England, while engaged in burying some cases of this compound in a pit beyond the city limits for safety.

It is noticeable that most of the accidents recorded have occurred in moving, transporting, or liquefying the compound after eongelation, and not in blasting.

For farther information see the following patents:—

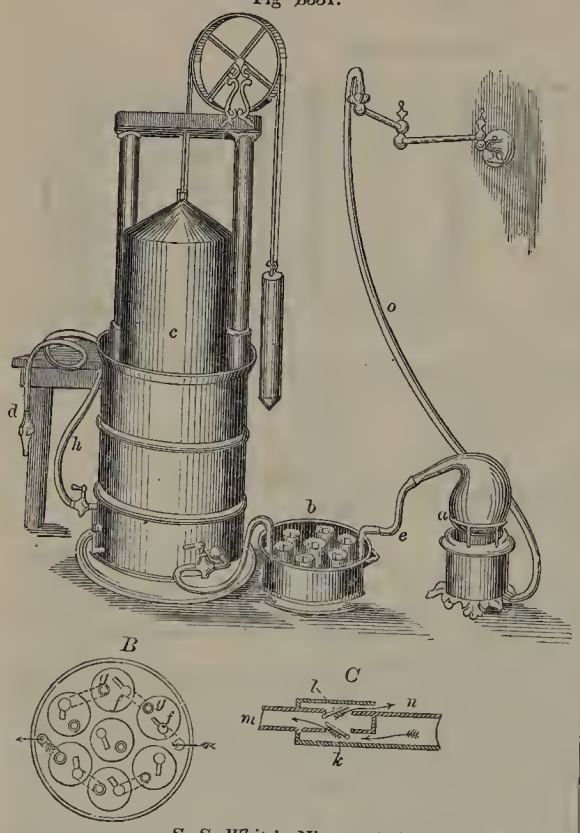
No. 50,617, Nobel, 1865; reissued, 1869.
No. 56,620, Shaffner, 1866.
No. 57,175, Nobel, 1866.
No. 60,567, Shaffner, 1866.
No. 60,572, Shaffner, 1866.
No. 60,573, Shaffner, 1866.
No. 76,499, Mowbray, 1863.
No. 78,317, Nobel, 1868.
No. 85,906, Chester and Burstenbinder, 1869
No. 86,701, Shaffner, 1869.
No. 87,372, Shaffner, 1869.
No. 93,752, Shaffner, 1869.
No. 93,753, Shaffner, 1869.
No. 93,754, Shaffner, 1869.
No. 93,756, Shaffner, 1869.
No. 98,382, Horsley, 1869.
No. 98,425, Shaffner, 1869.
No. 98,426, Shaffner, 1869.
No. 98,427, Shaffner, 1869.
No. 98,854, Ditmar, 1870.
No. 99,069, Ditmar, 1870.
No. 99,070, Ditmar, 1870.
No. 106,606, Mowbray, 1870.
No. 106,607, Mowbray, 1870.
No. 112,848, Roberts, 1871.
No. 112,849, Roberts, 1871.
No. 112,850, Roberts, 1871.
No. 117,577, Taylor, 1871.
No 120,776, Roberts, 1871.

Ni-tro'le-um. A name for NITRO-GLYCERINE (which see).

Ni-trom'e-ter. An instrument for detecting the quality of niter.

Ni'trous-ox'ide Ap'pa-ra'tus. Nitrous oxide (N O), eommonly ealled laughing-gas, is frequently employed in dental surgery as an anæsthetie. It may be procured by simply heating nitrate of ammonia, or by the action of nitric aeid on copper or mercury.

Fig 3331.



S. S. White's Nitrous-Oxide Apparatus.

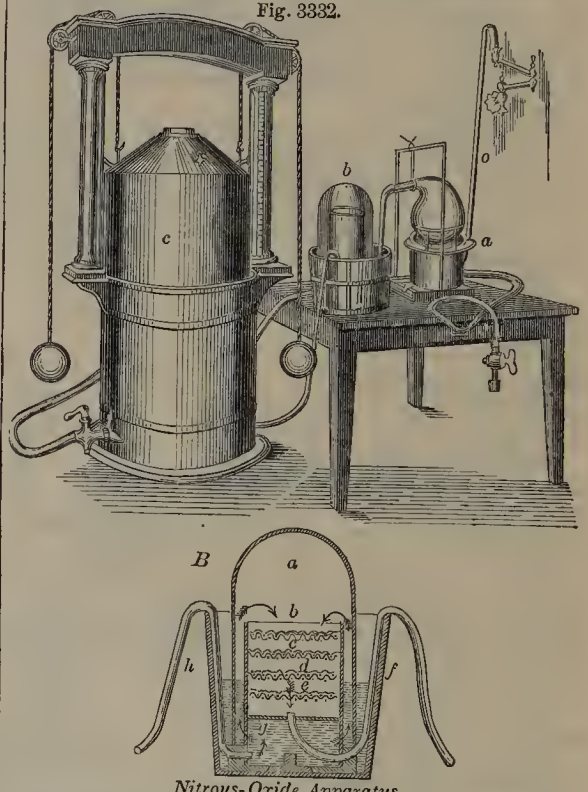
The apparatus shown in Fig. 3331 is designed for the production and retention of this gas on a large scale, for the purpose of inhalation.

It consists of a retort and heater *a*, purifier *b*, gasometer *c*, which may eontain 40 to 50 gallons, and inhaler *d*. The gas generated in the retort passes through the pipe *e* to the purifier *b* containing a solution for removing impurities; in this are arranged seven inverted tumblers, shown in plan at *B*, through which the gas successively passes from one to another by the pipes *f g*; on leaving the last tumbler it is received into the gasometer *c*.

The inhaler *d*, shown in seetion at *C*, is connected by pipe *h* with the gasometer, and has two valves *k l* opening in opposite directions. On applying the mouth to the end *m* and making an inhalation, the valve *k* opens, while during the act of expiration it closes; the valve *l* is at the same time opened, allowing the gas, which has passed through the lungs, to escape through the opening *n*. *o* is a pipe conveying gas to a burner which heats the retort.

The general arrangement of the apparatus shown in Fig. 3332 is identieal with the foregoing, but the purifier *B* consists of a glass dome *a* covering the

Fig. 3332.



Nitrous-Oxide Apparatus.

cylinder *b*, which has several disks *c d e* of wire-gauze on which lime is placed for absorbing impurities. The gas enters through the pipe *f* opening above the diaphragm *g*, and eirculates, as indicated by the arrows, through the cylinder *b*, finally passing into the gasometer by the pipe *h*.

Johnston Brothers of New York furnish liquefied nitrous-oxide gas for dental purposes. They compress 1,200 gallons of gas into a cylinder 24 inches long and 6 inches in diameter; or over 100 gallons into a cylinder 12 inches long, 3½ in diameter. The pressure is about 800 pounds to the square ineh at 60°. It is shipped in chilled wrought-iron bottles with steel faucets.

Nob. A head; a knob.

(*Artillery.*) The plate under the swing-bed for the head of an elevating screw.

Nobert's Test-plate.

"F. Nobert, a manufacturer of optical instruments, residing at Barth, Pomerania, has, during the last twenty-five years, been renowned for producing the finest rulings on glass which have hitherto heen executed. These rulings are used for two purposes; as a test of the defining power of microscopic objectives, and as a means of determining the wave-lengths of the undulations of the several portions of the solar spectrum.

"Those intended for microscopic use are kuown as *Nobert's test-plates*. They are executed ou the uuder surtace of a piece of exceedingly thin glass (1 200 of an inch thick or less), which is either cemented to a slip of ordinary plate-glass such as is used in mounting microscopic objects, or, in exceptional cases, to another piece of thiu glass, ahout 1 100 of an iuch thick, the two heing mouuted over a circular hole drilled in a thin plate of brass. The latter arrangement is intended to permit the ruling to be illuminated from below by achromatic combinations of short focus.

"When one of these test-plates is examiued with the naked eye, it looks as if a siugle straight line not wider than a hair had been engraved beneath the glass cover, and this when held in the light glows with spectral colors as the plate is moved. If this apparent line be examined with a microscope of adequate power, it is found to be composed of a number of bands, each consisting of a group of fine lines, the distances between which vary according to a fixed rnle. Nohert has issued a number of kiuds of these plates, which differ in the number of hands and in the distance of the lines of the finest band from center to center. The following are the best-known varieties, arranged in the order of the date of their issue: —

Designation of Plate.	Distance of the lines from center to center in fractions of a Paris line.*	
	In the coarsest hand.	In the finest hand.
Ten-hand plate	1/1000	1 4500
Fifteen-band plate	1/1000	1/5000
Twenty-hand plate	1/1000	1/6000
Thirty-band plate	1 1000	1/8000
Nineteen-band plate	1/1000	1/10000
New twenty-band plate	1 1000	1/20000

* The Paris line is rather longer than the English line. One English inch equals 11.25936 Paris lines.

"Of these, the nineteen-hand plate has heen most used during the last ten years. The new twenty-hand plate has only recently appeared, as will be explained hereafter.

"The following table gives the number of lines in each band of the nineteen-han l plate and of the new twenty-band plate, so far as known, with the distance of the lines of each band from center to center, in fractions of a Paris line, and the nnmber of times this distance would be contained in an English inch.

Numher of Band.		No. of lines in each band.	Distantia linearum in fractions of Paris line.	No. of spaces to the English inch.
In the nineteen-band plate.	In the new twenty-band plate.			
I.	I.	7	1 1000	11,259
II.		10	1 1500	16,889
III.	II	13	1 2000	22,519
IV.		15	1 2500	28,148
V.	III.	17	1 3000	33,778
VI.		20	1 3500	39,408
VII.	IV.	23	1 4000	45,037
VIII.		25	1 4500	50,667
IX.	V.	27	1 5000	56,297
X.		30	1 5500	61,926
XI.	VI.	34	1 6000	67,556
XII.		37	1 6500	73,186
XIII.	VII	40	1 7000	78,816
XIV.		43	1 7500	84,445
XV.	VIII.	45	1 8000	90,075
XVI		48	1 8500	95,705
XVII.	IX.	51	1 9000	101.334
XVIII.		54	1 9500	106,964
XIX.	X.	57	1 10000	112,594
	XI.	Not known.	1 11000	123.853
	XII.		1 12000	135,112
	XIII.		1 13000	146,372
	XIV.		1 14000	157,631
	XV.		1 15000	168,890
	XVI.		1 16000	180,150
	XVII.		1 17000	191,409
	XVIII.		1 18000	202.668
	XIX.		1 19000	213,928
	XX.		1 20000	225,187

"It will be seen hy this tahle that the first ten hands of the new tweuty-hand plate correspond to the alteruate bands of the nineteen-band plate, and that the ten remaining bands arc all closer than its nineteenth hand, the lines of the twentieth band heing just twice as close.

"Long after copies of the nineteen-band plate had found their way to all parts of the civilized world, the lines of the finer hands remained invisible to the most skillful microscopists. This resulted not merely from the closeness of the lines, hut also from their extreme delicacy and paleness. Nohert, who was himself unable to see them, supposed that there was a physical reason why lines separated by a distance less than the shortest wavelength of visible light, would forever resist resolution; an opinion which has since been shown to rest upon a misinterpretation of the physical law invoked. In 1869, however, the lines of the sixteenth, seventeenth, eighteenth, and nineteenth bands were not only seen and counted, but they were photographed by Dr. J. J Woodward and one of his assistants in the Army Medical Museum at Washington, and the feasihility of resolving them was thus placed heyond douht. Prior to this, various microscopists had helieved that they had resolved these hands, but as they had not succeeded in ascertaining the number of lines in each individual band their claims were not universally accepted.

"On the receipt of the Museum photographs, Nohert for the first time acknowledged that the highest four bands had been resolved, and promised that he would endeavor to rule still finer lines. The new twenty-hand plate was the result of his suhsequent efforts. One of these plates was furnished by him to President Barnard of Columbia College in 1872, and in the spring of 1873 another was received at the Army Medical Museum. Systematic endeavors with the hest modern objectives have failed as yet to resolve any of the hands of this plate heyond the tenth, and hence perhaps some will he disposed to deny that they have actually heen ruled as stated, hut it must he remembered that similar doubts were raised with regard to the finer hands of the nineteen-hand plate before they were resolved; and the appearances presented by the new hands are so similar to those of the higher bands ot the old plate, when viewed hy a power inadequate to resolve them, that it seems probahle that Nobert has again succeeded in outstripping the present resolving power of our best microscopes, as he did in former times; that the new hands are actually ruled as claimed, and that they will serve, as the higher hands of the old plate did, a most useful purpose hy stimulating practical opticians to still farther improvements in the construction of objectives.

"The method hy which Nobert prepares these rulings has been kept secret. Various attempts have heen made to imitate them, but without success, hecause no one else has been ahle to construct a point suitahle for executing such work; the best diamond splints make marks which are ragged and uneven when examined by high powers, and diamond-points, prepared hy grinding with diamond-dust in the most careful manner, are yet too coarse to imitate the heauty and regularity of even the lines of the coarsest hands of Nobert's plates. Could a suitable point he prepared, there would appear to he no serious difficulty in constructing a machine to execute the rulings.

"Used, with suitable precautions, as a test of the resolving power of microscopic objectives, the plates of Nohert appear to offer great advantages over diatoms and other natural objects. In the case of the latter, individuals of the same species vary greatly in dimensions and in difficulty of resolution, while in Nohert's plates the variation is reduced to a minimum. The ruling is executed with such marvelous precision that no perceptihle differences can be detected in the dimensions or difficulty of similar hands on different plates, and they afford also a convenient means of assigning numerical values to the resolving power of the objectives tested.

"To resolve the highest hands of the nineteen-band plate or the corresponding ones of the twenty-band plate, objectives of the best quality are required, and should he used with oblique illumination. A coal-oil lamp may be employed as the source of light, hut the most satisfactory results are attained hy using monochromatic (hlue) sunlight, which may he obtained by means of a suitahle prism, or by reflecting the snulight from a mirror through a thin layer of a saturated solution of the ammonio-sulphate of copper.

"Any of the test-plates of Nobert can also be used for determining the wave-lengths of light. Nobert has, hesides, prepared a variety of plates especially for this purpose When closely ruled lines on glass are illuminated hy an ohlique pencil of light, and viewed with a low power of very small aperture, the line of vision being perpendicular to the plaue of the ruling, the latter will appear as a colored hand, the color varying with the angle which the luminous pencil forms with the plane of the ruling. Now it has heen shown that this angle, the wave-length of the color seen, and the distance of the lines apart, stand in a fixed mathematical relation to each other; so that if the distance of the lines is precisely known and the angle carefully measured, the wave-length of the color seen can readily he computed. The fidelity with which Nobert's rulings are executed at the distances stated hy their maker gives them a high value for this purpose. One of the most ingenious of these plates is the so-called *wave-plate*, in which there are seven hands, the lines of which stand in such a relation to each other as to distance, that when they are illuminated with light

thrown with such obliquity that the first or coarsest band appears red, the second is orange, the third yellow, the fourth green, the fifth blue, the sixth indigo, and the seventh violet. Viewed with a suitably high power these bands are seen simply as groups of fine black lines, the distances of which from center to center can readily be measured by a micrometer.

"For farther details with regard to Nobert's plates, the reader may consult F. Nobert in 'Poggendorff's Annalen,' Bd. 58, 1852. The treatises of Carpenter and Harting on the Microscope, and a number of papers published in the 'Quarterly Journal of Microscopical Science,' and the 'Monthly Microscopical Journal,' since 1868."

Kindly furnished for this work by Colonel J. J. Woodward, M. D., United States Army.

Nock. (*Nautical.*) The upper front corner of a 4-cornered, fore-and-aft sail; such as a *spanker*, a *trysail*. Also called the *throat*.

Noc'to-graph. *a.* A writing-frame for the blind.

b. A nightly account or report. The converse of the *diary*.

c. An instrument or register which records the presence of watchmen on their beats.

Noc-tur'nal; Noc'tur-la'bi-um. (*Nautical.*) An instrument to take the altitude or depression of some of the stars about the pole, in order to find the latitude and the hour of the night. — ADMIRAL SMYTHE.

Nod'dy. A small, two-wheeled, one-horse vehicle.

Node. A small hole in the gnomon of a dial to indicate the hour by its light, as the gnomon itself does by its shadow.

Nog. 1. (*Mining.*) One of the square blocks of wood which are piled on one another to support the roof of a mine.

2. (*Building.*) A wooden block of the size of a brick, built into a wall as a hold for the nails of the finishing work which is nailed thereto.

3. (*Shipbuilding.*) A treenail driven through the heel of a *shore* which supports a ship on the *slip*.

Nog'ging. (*Building.*) A wall or partition of scantling with the interstices filled in with brick. Brickwork carried up in panels between *quarters*.

Nog'ging-piece. Horizontal scantling laid between courses occasionally.

Noils. Combings, waste, tangles, and knots of wool removed by the comb.

Non-cir'cu-lar Wheel. A wheel whose perimeter is not circular; a pair of such being used to transmit a variable velocity ratio between a pair of parallel axes. Such wheels may be elliptical, scroll, hyperbolar, etc.

Non-con-dens'ing Steam-en'gine. A steam-engine, usually high-pressure, in which the steam on the non-effective side of the piston is allowed to escape into the atmosphere. In contradistinction to an engine in which the steam in advance of the piston is condensed, to create a partial vacuum and thus add to the effective value of the steam which impels it.

Non-condensing engines are lighter than *condensing* engines of equal power, as the latter contain a large number of bulky and heavy parts of which the other is destitute. Condensing engines are generally more economical of fuel.

The comparative lightness and compactness render the *non-condensing* engine suitable for locomotives and steamboats of light draft. The Western and Southern rivers are comparatively shallow at certain points or seasons, and *non-condensing* engines are used in those sections of the country. The Eastern rivers and Northern lakes are deep, and the *condensing* engine is used thereon.

Pumping and *factory engines* of large size are usually *condensing*. A notable example to the contrary is George Shield's pair of horizontal pumping-engines at the Cincinnati Water-Works. They were put in operation about 1846.

The escaping steam of non-condensing engines is usually made to heat the feed-water. In locomotives it is exhausted into the chimney to increase the draft. This was first done by Trevethick in 1802. It was at first designed probably to put out the sparks, avoid noise, and get rid of the steam without the addition of a second pipe.

The following from Haswell is based upon a uniform steam pressure of 60 pounds per square inch (steam gage), cut off at one half the stroke, deducting one sixth for friction and losses, with a mean velocity of piston of 250 feet per minute: —

Nominal Horse-Power of several Non-condensing Engines.

Horses' power.	Diameter and stroke of cylinder.	Revolutions. Min.	Horses' power.	Diameter and stroke of cylinder.	Revolutions. Min.	Horses' power.	Diameter and stroke of cylinder.	Revolutions. Min.
No.	Ins. Ft.		No	Ins. Ft.		No	Ins. Ft.	
9	6×1	125	46.1	12×4.5	32	159.7	22×5.5	30
9.2	6×1.5	85	55.3	14×3	47	160 7	22×6	28
12.2	7×1	125	56.3	14×3.5	41	163.6	22×6.5	26
12.5	7×1 5	85	58	14×4	37	169.4	22×7	25
16.3	8×1 5	85	60	14×4.5	34	183.7	24×5.5	29
16.9	8×1.75	75	60.8	14×5	30	193.5	24×6	28
21 1	9×1.5	87	64.8	15×3	48	194.7	24×6.5	26
21 3	9×1.75	75	66.1	15×3.5	42	193.5	24×7	24
21.4	9×2	66	66.6	15×4	37	198.7	24×7.5	23
21.5	9×2.5	53	66.8	15×4.5	33	227.1	26×6	28
26.1	10×1.5	87	67.5	15×5	30	228.5	26×6.5	26
26 6	10×1.75	76	77 1	16×3.5	43	227.1	26×7	24
27.2	10×2	68	77 8	16×4	38	233.2	26×7.5	23
27.5	10×2.5	55	78.3	16×4.5	34	237 9	26×8	22
28.2	10×3	47	79.4	16×5	31	266	28×6.5	26
28.7	10×3.5	41	81.7	16×5.5	29	274.4	28×7	25
28.8	10×4	36	82.9	16×6	27	270.5	28×7 5	23
33.9	11×2	70	99.1	18×4.5	34	275.8	28×8	22
33.3	11×2 5	55	103.7	18×5	32	279.9	28×8.5	21
33.4	11×3	46	103.4	18×5 5	29	304.2	30×6.5	26
33.9	11×3 5	40	105	18×6	27	315	30×7	25
34.9	11×4	36	128	20×5	32	324	30×7.5	24
39.2	12×2	68	127.6	20×5.5	29	331.2	30×8	23
39.6	12×2 5	55	129.6	20×6	27	336.6	30×8.5	22
40.6	12×3	47	130	20×6 5	25	340.2	30×9	21
41.3	12×3.5	41	134.4	20×7	24	359.1	30×9.5	21
41.5	12×4	36	154 9	22×5	32	360	30×10	20

Non'i-us. A sliding graduated scale on a graduated plate adapted to subdivide the divisions of the scale on which it moves. So called from Peter Nonnez or Nonnius (his Latinized name), a Portuguese mathematician of Alcazar, born in 1497. See VERNIER.

The nonius scale of a quadrant or sextant is fixed to the oblong opening near the lower end of the index-bar. It divides degrees into minutes and these into seconds.

Non-pa-reil'. (*Printing.*) A size of type between agate and minion.

Agate.
Nonpareil, 143 ems to the foot.
Minion, 128 ems to the foot.

Noo'dle. (*Domestic.*) A strip of rolled dough, used in soup.

A noodle-making machine, patented January 13, 1874, has a frame in which two rollers revolve, with a plate between them, which roll out a sheet of dough. Above the upper roller is another, armed with a series of circular disk-cutters that project below slots in a metallic guard. The metallic plate, with the sheet of dough upon it, is passed between the upper plain roller and the roller with the cutters, thus forming the dough into strips.

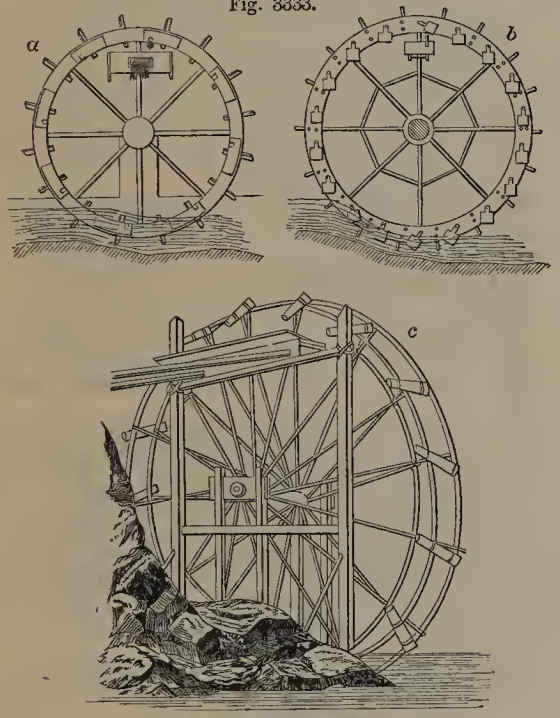
No'ri-a. A water-raising device (Arabic, *Na' Ura*), which has traveling pots or buckets, submerged below and discharging at their point of greatest elevation.

The modes of constructing and operating are various : —

1. The original form seems to be a wheel with buckets or pots each pivoted to the rim at a point above its center of gravity, so as to hang perpendicularly. These are submerged in the water at their lowest point, and, rising, are upset by contact with a fixed obstacle at their highest point, discharging into a chute or trough which conducts the water to a reservoir. *a b*, Fig. 3333, show two forms of the device, — a wheel with boxes in its rim, and one with suspended buckets.

The Chinese *noria c* is made of bamboo, excepting the hub of the wheel and the posts on which it rests. The buckets are bamboo tubes, inclined so as to hold nearly to their capacity till they reach their culminating-point. The wheels are from 20 to 40 feet in diameter, according to situation, and are driven by the impinging of the stream upon peripheral float-boards. One described by Sir George

Fig. 3333.



Norias, or Bucket-Wheels.

Staunton was 30 feet in diameter ; had 20 buckets, 4 feet long and 2 inches diameter in the clear, holding $\frac{6}{10}$ of a gallon ; 12 gallons to a revolution, 4 revolutions and 48 gallons per minute ; over 300 tons per day.

The reference to water, and to means for obtaining it, are very frequent in the Bible. In the much-misunderstood text in Ecclesiastes we find a reference to the *noria* : —

"Or ever the silver *cord* be *loosed*, or the golden *bowl* broken, or the *pitcher* be broken at the fountain, or the *wheel* broken at the cistern."

These wheels have been used from time immemorial in raising water for irrigation, in Assyria, Egypt, Persia, Syria, Arabia, and Palestine, and no doubt in China and India, but have undergone many modifications.

Thompson, in his "The Land and the Book," says : "This system of water-wheels is seen on a grand scale at Hums Hamath and all along the Orontes. The wheels there are of enormous size, 80 or 90 feet. They are driven by the river itself, paddles being attached to the rim, upon which the stream is turned by means of a low dam, carrying the huge wheel around with its load of ascending buckets. There is perhaps no hydraulic machinery in the world by which so much water is raised to so great an elevation at so small an expense. With their loads they slowly revolve on their groaning axles, each singing a different tune, — a concert wholly unique and half infernal, which, once heard, will never be forgotten."

The wheel with jars attached is one form of the Roman *antlia*, known by the same name also in Greek.

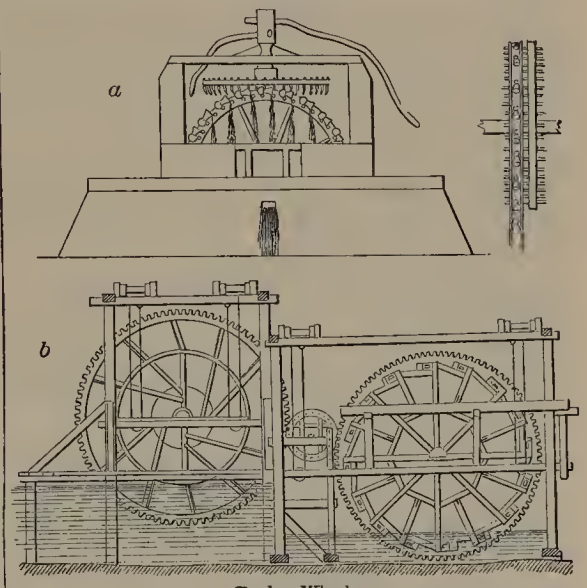
A substantially similar form of wheel is used on the river Eisbach, in the Tyrol ; it also is rotated by the force of the current impinging on radial floats on or near the periphery of the wheel.

In other places in the East the wheel is driven by manual or animal power.

Another form of the *noria* is much used in Syria and Palestine, in raising water for irrigation (*a*, Fig. 3334). A central post has a circular sweep-pole, to which a mule is attached. Cogs on the central shaft engage others on a horizontal shaft, and operate the wheel upon which traverses a continuous rope furnished at intervals with jars or wooden buckets. The rope descends on one side with empty buckets and rises on the other side with full ones, which discharge into a chute leading to the cistern. These wheels are kept going day and night by relays of men and mules ; in some cases being the joint property and care of the inhabitants of a whole village.

The great bucket-wheel (*b*, Fig. 3334) employed by Perronet at the construction of the Bridge of

Fig. 3334.



Bucket-Wheels.

Neuilly, France, was 16½ feet in diameter, 4½ feet in width, and had 16 buckets and 118 cogs. The water-wheel by which the bucket-wheel was driven was 18 feet in diameter and had 128 cogs. The float-boards were 20 feet long, 3 feet wide, and were set at an angle of 15° with the radius. The lantern-wheels which acted as pinions to the large cog-wheels of the bucket-wheel and water-wheel were 4 feet in diameter and had 30 trundles. The axle of the trundles was 12 inches in diameter, and varied in length according to the relative proximity of the water-wheel and the bucket-wheel. The former was in the Seine,

and was rotated by the current of the river; the latter was in one of the coffer-dams which were constructed for the purpose of establishing foundations for the piers of the bridge. The axles of the lantern-wheels varied in length from 38 and 54 to 108 feet.

The term *noria*, having been applied generally to traveling water-raising buckets, has included the chain-pump, which in some treatises is called the *Spanish noria*. A new feature, however, is found in this, namely, a tube up which the pistons — no longer buckets — ascend.

The true Spanish *noria* has earthen pitchers secured between two ropes which pass over a wheel above and are submerged below. See CHAIN-PUMP.

No'ri-um. A metal discovered in combination or in company with zircon, and but little known

Nor'ma. 1. A square used by carpenters, masons, and others to lay off and test their work.

2. A pattern, templet, gage, or model.

Nor'man. (*Nautical.*) A bar or pin in a hole of a windlass or capstan, or on the cross-piece of the bitts, whereon to fasten or veer a rope or cable.

Nor-we'gi-an Stove. An apparatus which may be used either to retain heat derived from other sources or serve as a refrigerator. It consists of a square wooden box lined with a soft, non-conducting substance; cows' hair is the substance actually employed. The lid is similarly lined. The interior is arranged for one or more saucepans, which, when inserted in the stove, are completely surrounded by the material. The meat or other substance in the saucepan being brought to the boiling-point in the ordinary manner, the pan is inserted in place in the stove, where, the radiation of heat being prevented by the lining, the contents remain at a boiling heat a sufficient time to insure their being thoroughly cooked.

When used as a refrigerator, the lining prevents the access of warm air to the cooler object within. No heat is of course ever applied to the apparatus, which is designed merely to maintain the temperature of an object already heated.

It is only adapted for articles cooked by water or steam.

Nose. 1. (*Machinery.*) A pointed or tapering projection in front of an object.

2. A nozzle, as of a bellows, a pipe, a tuyere.

3. The beak or rostrum of a still.

4. (*Lathe.*) The end of a mandrel on which the chuck is secured.

Nose, Ar'ti-fi'cial. A prosthetic nose, made of india-rubber or gutta-percha, colored in imitation of nature and applied in place of the organ removed by disease or accident.

The taliacotian operation makes an artificial nose of the natural flesh and skin, which adhere to the prepared base and grow there. See RHINOPLASTIC PIN.

Nose-bag. A bag of stout canvas with a leather bottom, and having straps at its upper, open end, by which it may be fastened to a horse's head while he is eating the contained provender.

Nose-band. (*Saddlery.*) The lower band of the military bridle, passing over in front and attached to the cheek-straps. A *musrole*.

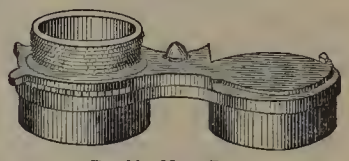
Collapsible nose-bands and similar devices to check runaway horses by stopping respiration are described in English patents: —

No. 1,576 of 1853.
No. 1,014 of 1858; pallets to stop nostrils.
No. 2,597 of 1858; pallets to stop nostrils.
No. 529 of 1859.
No. 1,184 of 1859; pallets to stop nostrils
No. 1,881 of 1860; pallets to stop nostrils.
No. 13 of 1861.
No. 1,624 of 1861; closing the blinkers.

Nose-bit. Another name for the *pump-bit* or *shell-auger*, used in boring out timbers for pump-stocks or wooden pipes. (See BIT.) A *slit-nose* bit.

Nose-hole. (*Glass-making.*) The open mouth of a furnace at which a globe of *crown-glass* is exposed during the progress of manufacture, in order to soften the thick portion at the neck, which has just been detached from the *blowing-tube*.

Fig 3335.



Double Nose-Piece.

Nose-key. (*Carpentry.*) A fox-wedge.

Nose-piece. 1. (*Optics.*) That which holds the object-glass of a microscope. Double, triple, or quadruple nose-pieces are sometimes attached to the nose of a microscope, and hold as many object-glasses of varying power, which are brought into requisition as desired.

2. (*Harness.*) The nose-band of a bridle.

Nose-pipe. The section of pipe containing the contracted orifice attached to the end of the blast-pipe, and placed within the tuyere of a blast-furnace.

The nose-pipes, through which the air issues into the furnace, vary in size with the nature of the coke and the ore. In Staffordshire they are usually from $2\frac{5}{10}$ to $2\frac{8}{10}$ inches in diameter.

Nos'ing. (*Carpentry.*) *a.* The rounded front edge of a *tread* which projects over the *riser* of a stair.

b. The prominent edge of a molding or drip.

Notch. An indentation cut in an object. A *croze*, for instance.

Notch-board. (*Carpentry.*) The board which receives the ends of the steps and risers in a staircase.

Notch'ing. 1. (*Railroad Engineering.*) A system of carrying forward excavations for railroads by a series of steps, upon which the work is simultaneously proceeding. Also called *gulleting*.

2. (*Carpentry.*) A mode of joining timbers or scantling in a frame. It is either square or dovetailed, and is made use of for connecting the ends of wall-plates and bond-timbers at the angles, letting joists down on girders, binders, sills, plates, or purlins.

Halving, *searfing*, and *cauking* are forms of notching, and form a *lap*-joint.

Notch'ing-adze. (*Carpentry.*) A light adze with a bit of large curvature or nearly straight for notching into timbers in making gains, etc.

Note. 1. (*Printing.*) These are of three kinds: —

a. Shoulder-notes. At the top of the page, giving book, chapter, and date, as in reference Bibles.

b. Side-notes. Marginal or *set-in* notes, containing abstracts of the text, as in law-books, or reference notes to parallel passages.

c. Bottom-notes. Containing commentaries and annotations.

2. A size of paper.

3. (*Music.*) A character whose shape indicates its duration, and whose place on the staff indicates its pitch.

Nou-e'. (*Surgical.*) A bandage with knots to press upon the parotid region after extirpation of the parotid gland.

Now'el. (*Founding.*) The inner portion of the mold for casting of large hollow articles, such as tanks, cisterns, and steam-engine cylinders of large size. It answers to the *core* of smaller castings. See *loam-work*, under MOLDING.

Noyl. The short refuse left upon the teeth of

the combs in preparing long-stapled wool for drawing and spinning. See WORSTED.

Noz'zle. 1. (*Hydraulics, etc.*) A spout or projecting ventage, as of —

a. The fireman's pipe at the end of the hose.

b. The snout of a pair of bellows or a tuyere.

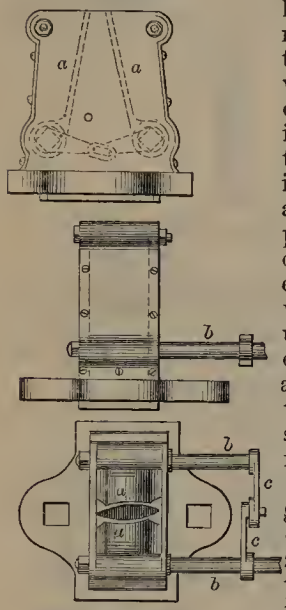
c. The projecting ventage of a faucet, of rain-water spouting, any discharge-pipe, etc., etc.

2. (*Steam-engine.*) *a.* The steam-port of a cylinder.

b. In English practice the *nozzle* includes those portions of a steam-engine in which are placed the valves that open and close the communication between the cylinder and the boiler and condenser in low-pressure or condensing engines, and between the cylinder and boiler and atmosphere in high-pressure or non-condensing engines.

c. The exhaust of *locomotives* and some other engines, such as the agricultural and saw-mill engines, known as *portable*, is directed into the chimney, the original purpose of which was to urge the draft. This was adopted in the locomotive of Trevethick in 1802, by Hedley in his locomotive of 1813, and by several of the competitors at the great trial of locomotives on the Liverpool and Manchester Railway in 1829. It is a valuable feature in agricultural engines, besides its function as a blast, in dampening the sparks which might set buildings or straw on fire.

Fig 3336.



Exhaust-Nozzle of Locomotives.

The locomotive engineer governs his blast by means of a variable exhaust-nozzle, which he opens or partially closes according to the requirements of the engine, its immediate duty, and the state of the fire.

In the illustration the nozzle is shown as having two leaves *a a*, on axes *b b*, which are moved simultaneously by means of the link *c c*, one of the axes *b* being connected to a hand-lever in the cab of the locomotive. For position of the nozzle, see PETTICOAT-PIPE.

Noz'zle-block. One in which two bellows-nozzles unite.

Noz'zle-mouth. The aperture. A *tuyere.*

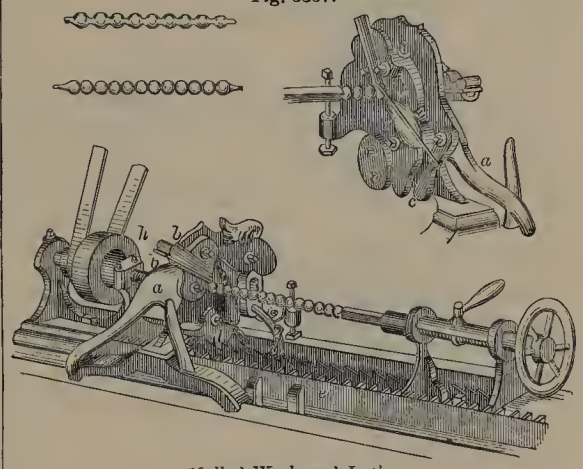
Noz'zle-plate. (*Steam-engine.*) A seat for a slide-valve of a steam-engine.

Nulled-work. Turned work resembling a series of beads strung on a rod. Much used in spindles and rolls for bedsteads, chairs, cribs, and other articles of furniture.

It is made in lathes whose cutter is automatically raised and depressed as the feed-screw draws it along on the bed. Fig. 3337 shows Alcott's lathe with Rennie's attachment. This consists of the lever *a*, with the adjustable knife-holders *b b* and attached arm *c*, back-rest *d* and rack *e*, with which the arm *c* engages.

In operating the machine, the lever *a* is turned up and the carriage propelled forward, the stick being rounded by the knife *g*; the carriage is then brought back to its first position, and by moving the lever up and down, the carriage is, through the arm *c* engaging with the rack *e*, advanced the proper distance and the nulls or beads formed by the cutter *h*.

Fig. 3337.



Nulled Work and Lathe.

A device for forming tenons on the ends of the piece may also be attached.

Num'ber-ing-ma-chine'. A machine for impressing consecutive numbers on account or record books (a *paging-machine*), coupons, railway certificates, bank-notes, railway tickets, etc.

The notes of the Bank of England were numbered by a machine invented by Bramah, 1806. It printed the numbers upon them consecutively at a rate which dispensed with the labor of 100 clerks out of 120 who were detailed for that duty during the issue of £1 notes.

The foundation idea is that of Blaise Pascal (1650), and consists of disks or wheels decimally numbered on their peripheries, the whole mounted on one axle, upon which they turn freely, acting upon each other in serial order, as explained under ARITHMOMETER. The first wheel of the series containing the units is moved one figure between each impact, and when the units are exhausted the tens come into action, and act in coincidence with the units, which continue their action. So on of the 100s, 1,000s, etc.

Bramah's numbering-machine, improved by Oldham, had 5 brass circles with studs carrying the numerals, so as to be able to number up to 99,999. The bank-note was presented on a table above, and the tympan brought down upon it, forcing the paper against the numbered studs, which were presented through openings in the bed. After each impression the first wheel of the train was rotated one spoke, bringing the next unit into presentation. The unit-wheel acted upon the 10-wheel as soon as the number 9 was reached and printed; the 10-wheel acted upon the 100-wheel, and so on, as seen in Watt's *registering-machine*, *gas-meters*, *arithmometers*, and numerous analogous machines and contrivances. The type-wheels were inked by a *dabber*. The machine had several crude movements, but is interesting as among the first of the automatic shifting instruments for serial indications or work, including the modern numbering and paging machines, calculating-machines and registers, the indicating-apparatus of meters, etc.

Trouillet's numbering-machine (French) is adapted either for hand or for use in a press. It consists of an axle containing a number of wheels, having on their perimeters the ten numerals separated by spaces. An instrument with 6 wheels will number from 000,001 to 999,999. The position, after every impact, is changed by means of a small lever that

rises alongside of the wooden handle, the immediate change being on the unit-wheel, and that acting upon the 10-wheel as its own numerals become exhausted, and it prepares to commence again at 1. So on with the 10 and 100 wheels to the end of the series.

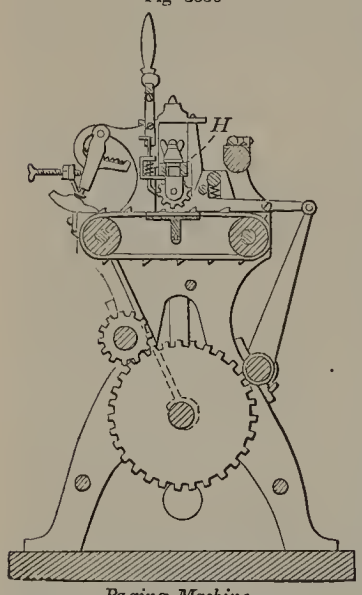
In the machine used in the Bank of France each note receives five impressions from the machine at once, distinctive of its relations to the remainder of the issue. One of these is its number of order, and increases from note to note; the others are significant of the class or of the particular series to which the note belongs, and change with the commencement of each new series. It is entirely automatic, taking up each note separately from the supply on one side, transporting it to the printing-table to be stamped, and subsequently removing it and depositing it in the receptacle for finished notes. The notes are lifted by a gentle force of aspiration produced by an air-pump, and acting through a hollow plate, perforated on the under side, and having a regular succession of movements.

Bailey's machine is designed for imprinting successive numbers on railway-tickets and their coupons at one operation. It also partially separates the coupons from each other and from the ticket, so that they may be readily torn apart.

Edmonson's prints the names of places on tickets, at the same time numbering them consecutively. The cards are fed singly to a horizontal table under a type-box containing the form, which is vertically reciprocated to receive ink from the rollers and to print the cards, which are held in place by guides extending from the feeding-tube to the receiving-tube. The numbers are engraved on the peripheries of wheels by which they are impressed on the cards.

Hoe's machine has peculiar mechanism for rotating the registering disks and a separate apparatus for inking them.

Fig 3333.



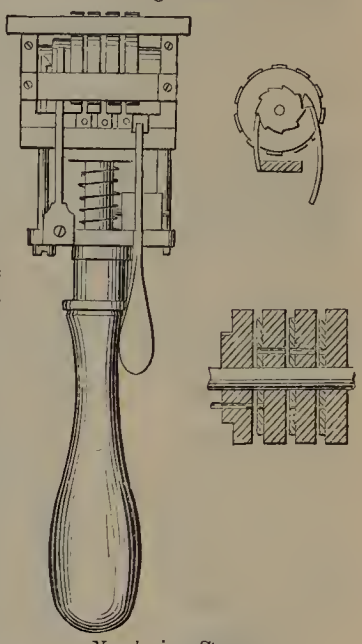
Paging-Machine.

In Hill's machine (Fig. 3338) the numbering-apparatus moves with the bed of a press operated in the ordinary manner, the inward movement of the bed-plate causing a spring-pawl to engage with a ratchet, and presenting the required number. A cross-head *H* is arranged to slide in vertical guides formed in the side-frames. In the longitudinal opening in the cross-head are fitted the stems of a number of hangers, each of which carries a numbering-wheel, and each wheel has a number of projecting types for imprinting the numerals. The desired movement is imparted to the numbering-wheels by rods, one of which is arranged to slide vertically in a bracket attached to each hanger. These rods have bent lower ends, which are made to engage with the teeth of a ratchet-wheel adjacent to the numbering-wheels, and thus impart the desired motion to the latter. See also PAGING-MACHINE.

Num'ber-ing-press. See NUMBERING-MACHINE.

Num'ber-ing-stamp. One for delivering consecutive numbers by successive impressions. A series of wheels have the series of figures from 0 to 9, and these have the usual connection by which pressure applied to an object sets in motion the unit-wheel. This is communicated to the next, carrying the tens, hundreds, and so on throughout the series. See NUMBERING-MACHINE.

Fig 3339



Numbering-Stamp.

Num'ber-print'-ing. The process whereby successive numbers are printed automatically on tickets, bank-notes, etc.

Various machines have been invented for this purpose, prominent among which are Bramah's, Shaw's, Edmonson's, and Trouillet's. See NUMBERING-MACHINE. Called a *numbering-machine* or *paging-machine.*

Nun-buoy. A buoy of a spindle shape, or formed of two cones joined at their bases.

Nurl'ing. The indentations or fluting on the edges of coins, the heads of temper and set screws, and similar objects. It is sometimes called *milling*, and in the mint is called *reeding.* The crenated edge on coin is intended to prevent clipping or filing the edges of the coin, which might otherwise be done to some extent without discovery, except by careful weighing.

Fig. 3340

Nurling-Tool and Nurled Head.

Nurling applied to the edges of temper-screws is to make them more easy to grasp by the fingers and thumb. It is very common in surveying-instruments, on compasses, dividers, calipers, etc., and generally upon all instruments where a screw is to be loosened or tightened, in the ordinary uses of the instrument.

A *nurling-tool* has a roller whose periphery has a sunken groove, indented so as to form the counterpart of the bead which is to be nurled on the head of the temper-screw. It is held against the portion of the object to be nurled, while the said object is rotated in a lathe.

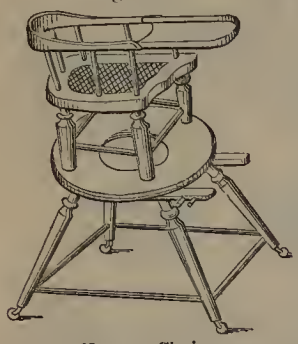
The nurling on the edge of a coin is made in the coining-press. By the great pressure (from 40 to 75 tons), the metal of the blank is forced outward into the indentations of the collar, which holds it while pressed between the two dies, forming the obverse and reverse respectively.

Nurl'ing-tool. (*Turning.*) A milling-tool. One for indenting the heads of temper and tangent screws, etc.

Nurs'er-y-chair. One for nursery uses; the example is convertible into a high-chair for table use, or with shelf in front for toys; or, when the upper part is removed, the lower forms a pan-chair.

Nurs'ing-bot'tle. One arranged to enable an

Fig. 3341

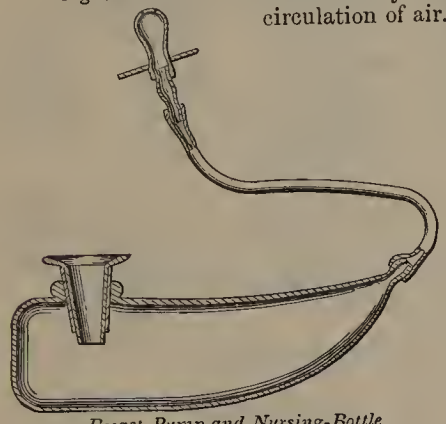


Nursery-Chair.

infant to draw milk from it by the natural action of sucking. Fig. 3342 is adapted to be used both as a breast-pump and a nursing-bottle. In Fig. 3343 the tubular stopper has a flexible leather tube extending up from the bottom of the bottle, so that it may nearly empty the bottle without drawing air. A nipple is attached to the projected end.

Nurs'ing-lamp. One for heating infants' food at night. The lamp-case is water-tight, and is submerged to heat the water in a bath. Pipes and chimneys afford a circulation of air.

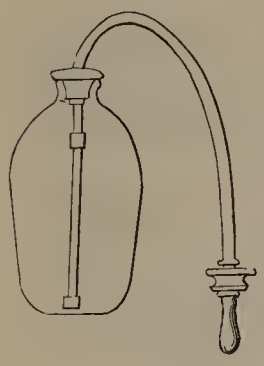
Fig. 3342.



Breast-Pump and Nursing-Bottle.

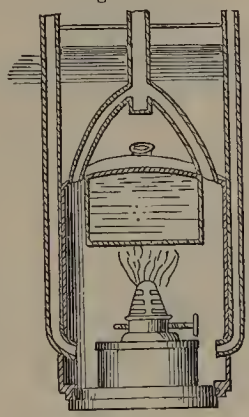
Nut. 1. (*Machinery.*) A piece of metal *a* tapped and adapted to be screwed on the end of a butt *b*.

Fig. 3343.



Nursing Bottle.

Fig. 3344.



Nursing-Lamp.

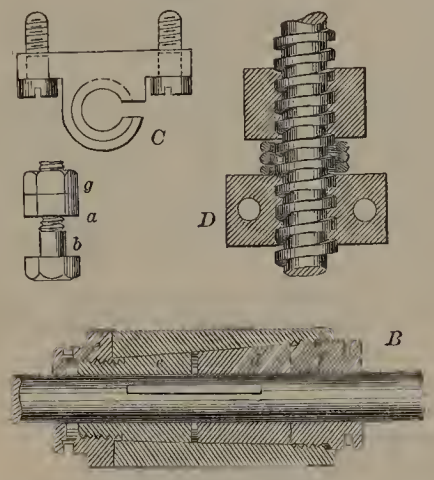
A second nut *g*, screwed down upon the first, is called a *jam-nut*, *check-nut*, *pinching-nut*, or *lock-nut*. (See NUT-LOCK.) A *nut-lock* is a device of any kind for fastening a nut; a *lock-nut* is a nut or bur which fastens another nut.

B shows a shaft and sleeve with two bushes *c d*, one drawn by a *drawing-nut c*, the other driven by a *forcing-nut f*.

C D are forms of elastic nuts. One has an opening which permits expansion, and the other screws down upon a spiral spring.

2. (*Vehicle.*) Axle-nuts are screwed on to the ends of the spindles or arms of carriage-axles, to

Fig. 3345.

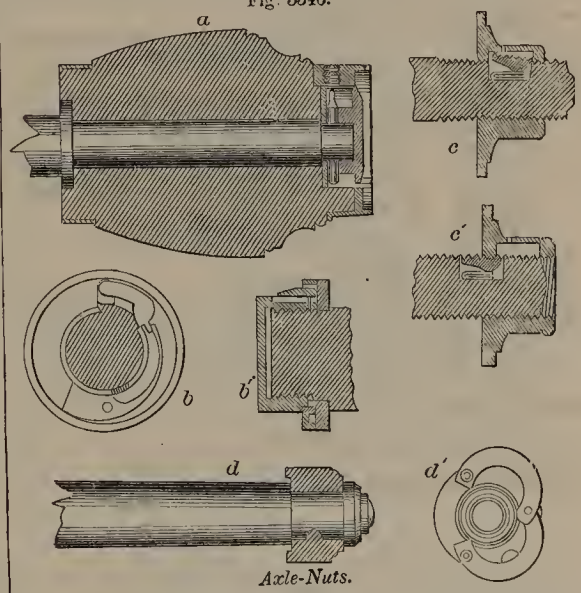


Bolts and Nuts.

hold the wheels on the spindles. The exercise of ingenuity in this line has been in devices to prevent the nuts from becoming unscrewed, and thus allowing the wheels to roll off. In the ordinary method, a closely fitting nut is screwed on the threaded end of the spindle, the threads on the near side of the carriage being left-hand threads, and those on the off side, right-hand threads, so that the ordinary motion of the wheels tends to roll the nuts on, and not off.

Sometimes the nut is fastened by a key of metal or leather, sometimes by a jam-nut. In the examples, *a* has a flanged cap instead of a screw-nut, and this is held by a transverse key slipped through a hole in the hub-band. *b b'* are views of an axle-nut

Fig. 3346.



Axle-Nuts.

which is secured on the axle by combining with it a spring friction-brake, which acts on the thread of the screw. The lever or arm of the brake extends beyond one of the faces of the nut, so that the brake may be withdrawn from the thread of the screw by the act of putting on the screw-wrench, to take off or put on the nut.

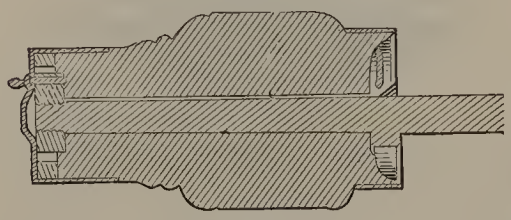
In *c c'*, when the nut is screwed up to its place, the lever-key is thrown into such position as to prevent the nut becoming unscrewed. To unscrew the nut, the lever-key is turned to a horizontal position

by entering a small iron pin through a hole and causing it to bear upon the key while the nut is started back. The two figures illustrate the respective positions of the lever-key.

In *d d'* the divided nut is clamped in a groove of the spindle, the shoulders of the groove being formed respectively of the enlarged, bearing portion of the spindle and of the outer boss. One portion of the nut may be hinged to the other, and the jaws opened to enable it to be placed in its seat ; or the two pieces may be locked together in any convenient manner.

In Fig. 3347, a cap covers in the outer end of the hub, and is not removed for the purpose of taking

Fig. 3347.

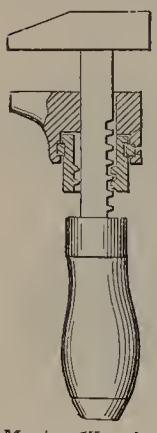


Young's Axle-Nut.

off the wheel. A pin is thrust in from the outside through a hole in the cap, and engages with a groove in the axle-nut, so as to lock the two together. The wheel being then rotated in the proper direction, the cap and nut revolve, and the latter is unscrewed from the end of the spindle, releasing the wheel without soiling the fingers by handling the nut.

Many devices to prevent nuts from becoming unscrewed are found in machinery subject to jar, and particularly in railroad-rail fastenings and fish-plates. See NUT-LOCK.

Fig. 3348.



Monkey-Wrench.

3. The screwed sleeve which operates the movable jaw of a monkey-wrench.

4. One of the rollers or crushing-cylinders of a cider-mill.

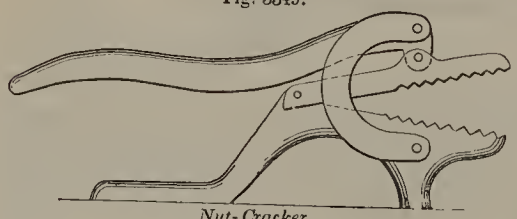
5. (*Nautical.*) A projection on the *shank* of an anchor to hold the *stock* in place.

6. (*Fire-arm.*) The tumbler of a gun-lock.

Nut-crack'er. An implement with jaws for cracking hard-shell nuts, such as hickory, walnut, Brazil, etc. The short arm of the lever is pivoted to the moving jaw, and it has fulcrum bearing in shackles which are pivoted to the fixed jaw and curved backward to give access to the jaws.

Nut-fas'ten-ing. See NUT-LOCK.

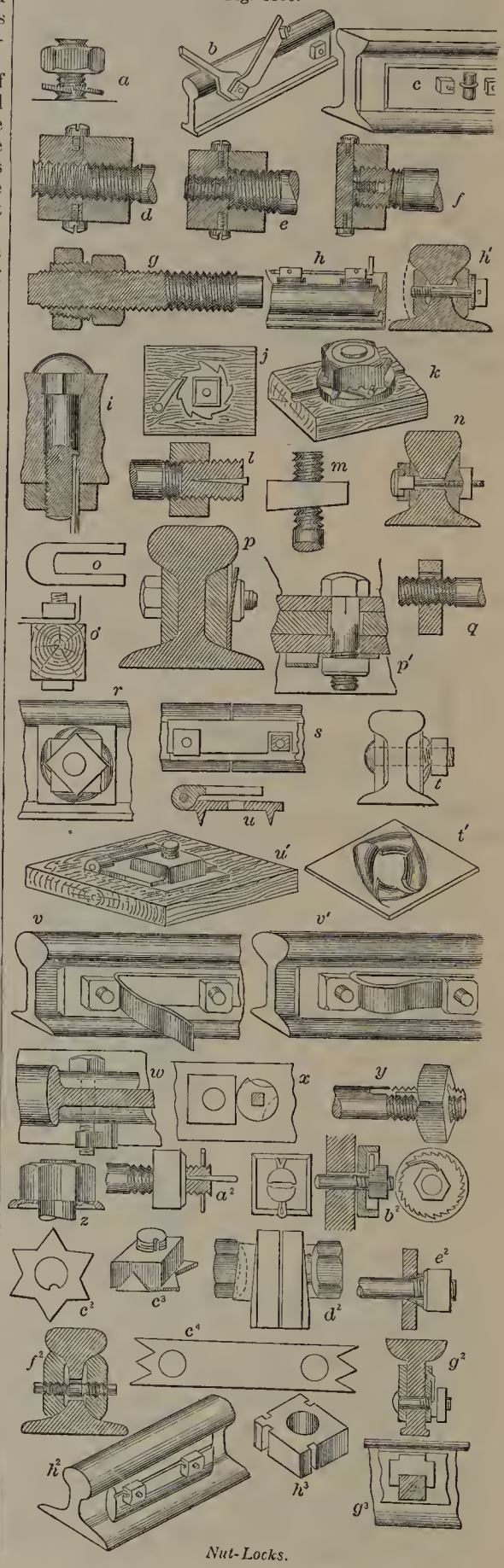
Fig. 3349.



Nut-Cracker.

Nut-lock. (*Machinery.*) A means for fastening a bolt-nut in place, preventing its becoming loose by the jarring or tremulous motion of the machinery. Such are used upon fish-bars of railways,

Fig. 3350.



Nut-Locks.

upon harvesters, and in many other places. In railways especially there has been a great demand to hold the nuts from being loosened by the shocks of the passing trains.

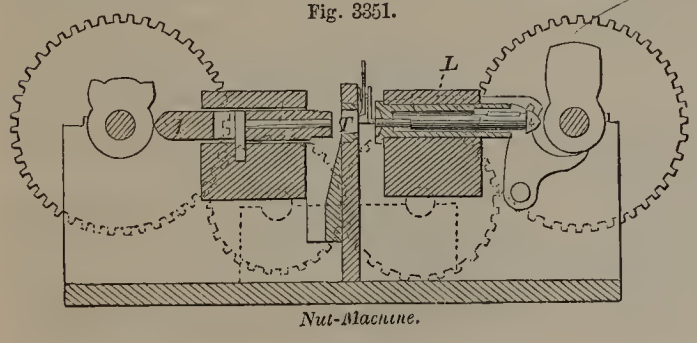
Fig. 3350 shows a number of these devices, some of which are American, others foreign. They require but little description, being simple and readily represented by drawing.

a has a washer cut obliquely so as to present cutting edges which sink into the nut and bar respectively.
b has a plate which fits between the two nuts of a fish-bar.
c has a plate which fits over the nuts, and is held by a staple and key.
d e are forms of jam-nuts, right and left handed, the outer one being of smaller diameter and allowing the lower nut to be slipped over it. They also have exterior set-screws.
In *f* the left-hand screw is interior, and its head jams against the face of the lower nut.
g has a conical screw portion, having longitudinal slits which allow it to be pinched down upon the bolt-screw by the outer nut.
h h' has a through-pin which transfixes the nuts.
i has a feather which lies in a longitudinal groove in the bolt and a spline-way in the nut.
j has a ratchet-washer and a click; the nut is partially imbedded in the washer.
k has pins which enter opposite grooves in the contacting faces of the washer and nut.
l has a split bolt and spreading wedge.
m has an unequal-sided washer, which causes one side to jam against the object and partially imbed itself.
n has a concave-faced nut which slips on to a seat on the washer or fish-bar.
o o' show a bifurcated washer, the legs of which are bent up against the nut.
p p' has a split washer, one part of which springs up against the side of the nut.
q is a gravitating nut, being heavier on one side.
r has a washer with wings which spring up against the sides of the nut.
s has a notched plate which slips over recesses in the nuts.
t t' has spring wings on the washer to hold the nut.
u u' are two views of a washer with a hinged section which holds the nut.
v v' show forms of flexible washer-strips.
w has a nut with a gravitating extension-piece.
x has a cam which jams against the nut.
y is a bolt with groove for spline, and a corresponding groove on each side of the nut.
z is a nut which jams down upon a yielding washer.
a^2 shows two views of one having a split bolt, and a wedge held by a key.
b^2 shows two views of a nut with internal ratchet and a spring-click on the bolt.
c^2 c^3 c^4 are the Noblet washer, which has a portion to turn up against the nut, and a farther portion which may be turned down against the object, if desired.
d^2 is the Nicholson (1852) bolt with a semi-spherical bearing surface, and nut made to suit.
e^2 is Adam's wedge-formed washer (1856).
f^2 has a right and left double-ended screw-bolt.
g^2 g^3 are two views of a form in which a washer beneath the nut has a lip which projects into a slot in the fish-bar.
h^2 has a long washer-slip with a piece turned up to form a key.
h^3 shows the grooved nut.

Nut-ma-chine'. A machine for forming nuts from the solid bar by cutting or swaging.

In Fig. 3351, the heated bar is placed against a gage, the slide *I* is forced forward and the blank is cut from the bar; the blank is forced into the die *T*, to which the rounded header has been advanced by the movement of the slide *L*. The advance of the punch perforates the nut and forces the piece into the hollow left by the recession of the slide *I*, whose second forward movement discharges the nut.

Fig. 3351.

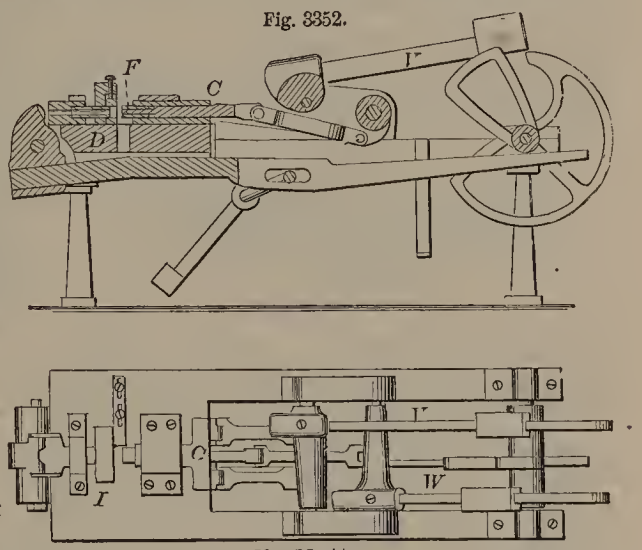


Nut-Machine.

In Fig. 3352, the blank is cut from the heated rod by the punch *D*. The ram *C* moves forward, carrying the holing-punch *F*, which is advanced, making the hole in the nut, after which they recede from each other, allowing the nut to be pushed out by the follower *I*. The swaging and holding punches are actuated by toggle-joint connection with the levers *V W*, producing a hammering action rather than a positive limited pressure.

In Fig. 3353, the sliding carriage *B* carries the cutter *H* (the cutting edge of which is beveled to cause any desired chamfer), and the borer *J*. The rod *E*, of hexagonal or other shape adapted to the kind of nut required, passes through similarly shaped rings, which prevent it from slipping during

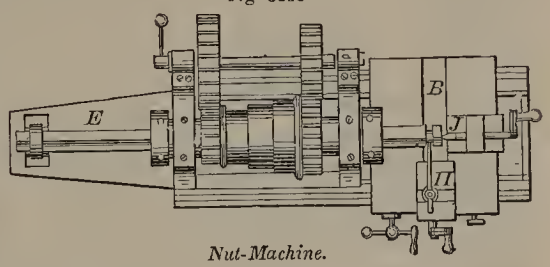
Fig. 3352.



Nut-Machine.

rotation. When 6 or 8 blanks have been cut by advancing the carriage, this is drawn back, the bar

Fig 3353.



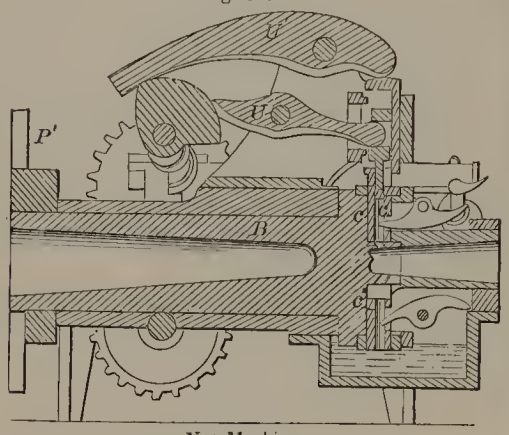
Nut-Machine.

is fed forward, and a new series of turning and drilling operations commences.

In the machine (Fig. 3354) the dies are arranged around the bed-roller *B*, which is intermittingly moved by the curved arms *P P'*, etc., so as to bring each die at the proper moment under a corresponding punch, actuated by the levers *U U'*, which cut out the nuts from the heated bar. They are then delivered from the die by plungers *c*. Punches, operated by cams, perforate the nut.

Nut'meg-grat'er. The largest four Banda islands are exclusively devoted to the growth of nutmegs, producing yearly 400,000 pounds of nutmegs and 130,000

Fig. 3354.



Nut-Machine.

pounds of mace. The nutmeg-tree grows 30 feet high, and resembles the orange, the pale yellow flowers and fruit, in various stages of maturity, be-

Fig. 3355

Nutmeg-Grater.

ing all together on the tree. The fruit is at first of a light green color, becoming yellow when ripe, with a longitudinal form. The external covering, at first thick and fleshy, and filled with acrid astringent juice, subsequently becomes dry and separates into two valves, disclosing the scarlet network known as mace. Within the latter is a thin brown shell containing the nutmeg. The fruit is gathered and divested of its outer coverings, the mace being carefully collected and dried in the sun. The nuts are dried in the sun, or in an oven, and smoked until the kernel rattles. The shells are then broken open and the kernels, having been steeped in lime-water, are packed in chests for exportation. The tree is produced from the seed, flowers in the ninth year, and continues bearing fruit and flowers all the year round for seventy years.

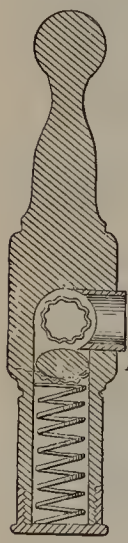
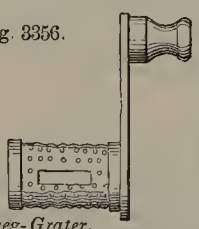


Fig. 3356.



Nutmeg-Grater.

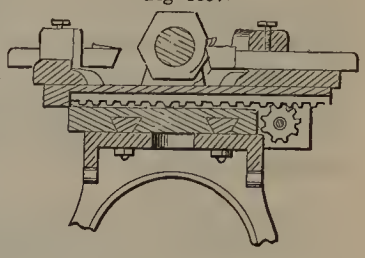
Besides the old-fashioned grater, in which the nut and the knuckles are impartially rasped, may be mentioned two other kinds. In Fig. 3355, the nutmeg *N* in the tube of the stock *A* is pressed by the spring against the grater *C*, which is reciprocated in the transverse opening.

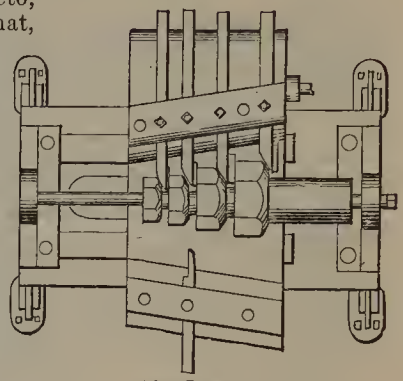
In Fig. 3356, the grater revolves in a stock, and the nutmeg is pressed against it by a spiral spring which bears against a removable cap, covering the opening by which it and the spice are introduced.

Nut-plan'er. A series of nuts of different sizes are screwed to the mandrel, and one side of the latter is a sliding tool-rest, to which are screwed a series of tools, having each two cutting edges, by which a number of nuts can be simultaneously faced and beveled.

Nut-roast'er. A rotary cylinder is confined in a hot-air case, and provided with gas-burners. A warming-apparatus, to which the tube that supplies gas to the roasting-apparatus is connected for supplying heat thereto, is so arranged that, after the nuts have been roasted and placed in the said warming-apparatus, the flow to the roasting-burner may be stopped, while that to the warming-apparatus continues.

Fig. 3357.

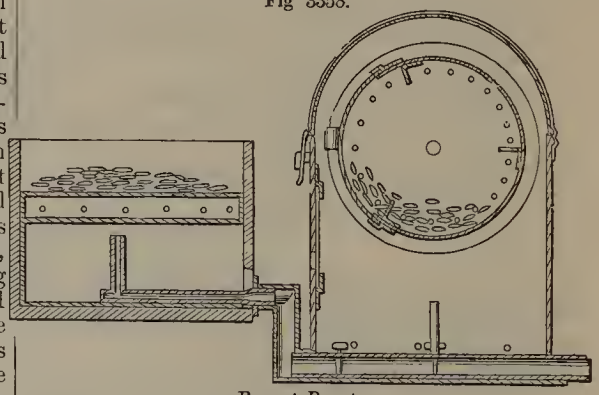




Nut-Planer.

Nut-shap'ing Ma-chine'. A machine for the purpose of shaping the external faces of hexagonal nuts. Six horizontal revolving cutters are arranged radially at the same level, and

Fig 3358.



Peanut-Roaster.

driven by a single bevel-wheel gearing into the six bevel-pinions that carry the cutter-spindles. The cutters are so fixed in their spindles that when the cutting edges of one tool are horizontal, those of the adjoining one are vertical, and they consequently miss one another in revolving, and can thus operate on work the faces of which are narrower than the breadth of the cutters; by this means the contiguous faces of hexagonal nuts are all shaped simultaneously by the revolving cutters. The nuts to be shaped are threaded upon a vertical center mandrel, to which a vertical feed-motion is given, traversing the nuts upward or downward in the middle of the revolving cutters; and the shaping of the six faces of the whole row of nuts on the mandrel is completed in a single traverse of the machine.

Nut-tap'ping Ma-chine'. For cutting screw-threads in punched nut-blanks. A machine resembling a drill-bench, with taps mounted on the ends of its mandrels.

Nut-wrench. A spanner for rotating nuts. See MONKEY-WRENCH, and list under WRENCH.

O.

Oak'um. (Anglo-Saxon, *acumba.*) 1. The coarse portion separated from *strick* (strike: A.-S., *stricau*) of flax or hemp in hackling.

2. Untwisted rope; used for *calking* the seams of a ship's plank, being forced thereinto by chisel and mallet. A first-rate ship of war requires 67,000 pounds of oakum to close the seams.

Oar. 1. (*Nautical.*) An instrument for rowing. A long paddle which rests in tholes on the gunwale in rowing.

A long oar, used occasionally to assist a vessel in a calm, is a *sweep*, and is operated by two or more men.

Small oars are *sculls;* one rower wielding a pair, sitting midlength of the *thwart*. *Sculling* a boat is performed by an oar shipped in a half-round hole at the stern, the oar being moved with a twisting action from side to side.

A *rigged oar* is one in which the oar is pivoted to the gunwale and moved by a rod, or otherwise by a rower sitting abaft it, so that he may face forward.

The *blade* of the oar, also known as the *wash*, is the broad flat part which is dipped into the water in rowing. The *blade* was formerly known as the *pala*, which survives in the term *peel*, yet applied to it. The term *pala* meant a spade; the older forms of paddles might be used for digging.

The *loom* of the oar is the shaft, beginning at the blade, and terminating in the *handle*, which is of rather smaller diameter than the *loom*, in order to afford a good hand-hold to the rower.

The oar when in use rests in *rowlocks* in the gunwale of the boat or between *thole-pins*, which are round pegs, inserted in holes bored in the gunwale.

To *boat* oars means to cease rowing and lay the oars in the boat.

To *feather* oars is to turn the blades in a horizontal position on lifting them from the water at the end of each stroke, to afford as little resistance as possible to the water in withdrawing, and to the air.

To *ship* oars is to place them in the rowlocks or between the thole-pins, ready for use.

An oar is frequently used for steering: in which case it is sometimes an ordinary oar shipped in a swiveled fork at the stern, as in whale-boats; or it may be a broad paddle attached to a long arm, working on a swivel near its center, or similar device, as is often the case in keel-boats, scows, etc.

To *lie on the oars* is to raise them from the water and hold them horizontally.

To *muffle the oars* is to put sheepskins in the rowlocks to prevent any sound in rowing.

To *toss the oars* is to raise them vertically, resting on the handles. It is a form of salute.

To *unship the oars* is to take them out of the rowlocks.

Single-banked is when the oars are rowed, one to each thwart, starboard and port sides alternately.

Double-banked is when two opposite oars are pulled by two rowers seated on the same thwart, or by two men at each oar.

The term *bank*, as applied to galleys, meant a tier of oars, as *double-banked*, *single-banked*, etc.

Says Pliny: "The Copæ invented the oar, and the Platæans gave it its broad blade." We suppose he means a fair distinction between the oar which rests in tholes and the paddle which is handled without receiving a fulcrum support on the gunwale.

The great ship of Ptolemy Philopator had forty ranks of rowers; the oars of the longest row were 38 cubits in length (say, 57 feet). These were loaded with lead on the part inside of the rowlocks, so as to evenly balance.

The scarcity of timber in Eastern lands had a great deal to do with the importance and peace of nations thereabouts. The possession of Lebanon and Bashan was not one of the least of the points in dispute between the two branches of the Macedonian Empire represented by the Seleucidæ and the Ptolemies.

These struggles fill up the time between the death of Alexander and the absorption of the country by the Romans, and form the history which was so remarkably portrayed in prophecy by Daniel several hundred years before. See the 11th chapter of Daniel.

While the fir-trees of Senir furnished the planks, and the cedars of Lebanon the masts, the oaks of Bashan contributed the oars of the famous galleys of Phœnicia. Being the great carriers of that day, and having direct dealings with Britain, India, Greece, Spain, Africa, and many ports whose names remain but whose localities are difficult to determine, these "princes of the sea" and artificers upon the land were in demand wherever an extra amount of intelligence, taste, skill, and daring was required. Two lands at least contributed the timber of their vessels, another the cordage, another the sails, another the oars, others the ivory, ebony, and sandalwood for adornment; Palestine contributed its iron.

Copper from the same land and the Caucasus was mingled with the tin from the far-off Cassiterides, the first contribution of Britain to the common stock of the world's merchandise, and which had the honor of forming with copper the alloy which made the brazen (*bronze*) laver and furniture of Solomon's Temple.

Though littoral Tyre was destroyed by Nebuchadnezzar, and insular Tyre by "young Ammon," the "rough he-goat, the king of Grecia," yet she survived in her colonies until the Roman maelstrom drew them all into its vortex and swamped the distinctiveness of many nations.

The best picture of the time is that given in Ezekiel xxvii. (which see).

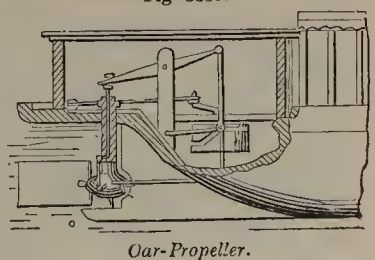
Machines are made for dressing, planing, riving, and splitting oars, but do not differ so specially from machines for getting out and dressing stuff for other purposes as to require elaborate description here.

2. (*Brewing.*) A blade or paddle with which mash is stirred in the tun.

Oar-lock. (*Nautical.*) A means of pivoting an oar on the gunwale. A ROWLOCK (which see).

Oar-pro-pel'ler. 1. A device to imitate by machinery the action of sculling. Two submerged blades at the stern are attached to an oscillating, vertical shaft and brought broadside to the water and feathered, alternately, so as to make an effective and a return stroke. The horizontal shaft

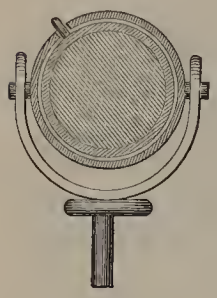
Fig. 3359.



Oar-Propeller.

of the blades receives an oscillation in a vertical plane, while the sleeve to which its hub is secured is oscillated in a horizontal plane, so that it receives a double oscillation, once around its own axis and also around the axis of the vertical shaft.

Fig. 3360.



Oar-Swivel.

In another form, the blades are oscillated with their rock-frame, and are feathered, so as to move forward edgeways and move backward flatways to propel the boat.

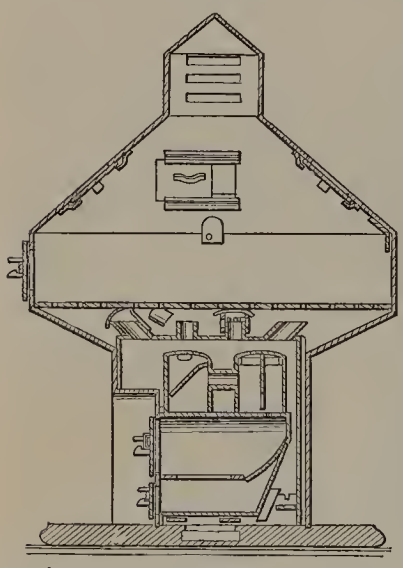
A canal-boat, propelled by oars, was used on the Sankey Canal, Lancashire, England, in 1797. The oars made 18 strokes per minute, and were operated by a steam-engine.

Oar-swiv'el. A pivotal device for an oar on the gunwale. A *rowlock*. In the example, the oar is hung in gimbals, which allow it vibration in any plane, and it has besides a capacity for rotation on its own longitudinal axis in feathering. See ROW-LOCK.

Oast. A hop-drying kiln.

The kiln has an upward draft, the floor being perforated and the hops lying upon hair-cloth. In the example, the furnace is covered by an arch of brick-work or metal, forming an air-chamber around the furnace from which the air is conveyed to the foraminous bottom of the kiln.

Fig 3361.



Oast.

Ob'e-lisk. 1. A quadrangular, slender stone shaft, with a pyramidal apex. The width of the base is usually about one tenth of the hight, and the pyramidal apex has about one tenth of the whole length. It is Egyptian in its conception and execution. Obelisks were erected in pairs, and are yet numerous on the ancient sites, and no doubt many prostrate ones are buried in the soil of Egypt, which has risen from the deposit of the Nile 9 feet in 1,700 years at Elephantine, and 7 feet at Thebes. The deposit of mud at Thebes, therefore, since Amunoph I., would be about 17 feet.

There are about a dozen Egyptian obelisks erected in Rome. The largest is that from Heliopolis. It is of granite, and now stands before the north portico of the Church of St. John Lateran, where it was erected in 1588. Its whole hight is about 149 feet; without the base, 105 feet. It was removed to Alexandria by Constantine, and to Rome by his son Constantius, and placed in the Circus Maximus. It was overthrown, broken into three pieces, and a piece was removed from its base before re-erecting. It weighs about 985,600 pounds. Its partner yet stands at Heliopolis. It is marked with the name of Osirtasen I., about 2100 B. C. Roman obelisks were also imported by Augustus and Caligula.

Other obelisks are found at Constantinople, Paris, Arles, Florence, etc.

The Egyptian obelisks are usually of granite, but there are two small ones in the British Museum made of basalt, and one at Philæ of sandstone. The date of the Flaminian obelisk, which is covered with hieroglyphics, is supposed to be about 1600 B. C.

The obelisk in Paris, erected in 1833, was brought from Luxor. It is 76 feet in hight. Of the needles of Cleopatra, so called, one is standing, 63 feet in hight, and the other is lying upon the ground.

"The mode of raising an obelisk seems to have been by tilting it from an inclined plane into a pit, at the bottom of which the pedestal was placed to receive it. A roller of wood was fastened at each side to the end of the obelisk, which enabled it to run down the wall opposite to the inclined plane to its proper position." — WILKINSON.

For a full description of the mode of moving and re-erecting an Egyptian obelisk, see the quarto "L'Obélisque de Luxor, Histoire de sa Translation à Paris," Paris, 1839. See also Cresy's "Cyclopedia," ed. of 1865, pp. 38, 40; also pp. 1013–17.

2. A reference-mark in printing (†); also called a dagger.

Ob'ject-find'er. (*Optics.*) A means of registering the position of a microscopic object in a slide, so that it may be readily found in future.

Maltwood's finder is a glass slide $3 \times 1\frac{1}{4}$ inches with a scale occupying 1 square inch ruled into 2,500 squares. See "Beck on the Microscope," p. 67.

Ob'ject-glass. (*Optics.*) The glass at that end of a telescope or microscope which is presented toward the object. The *objective*. By it an image of the object is formed, to be viewed by the eye-glass. In good instruments of either kind the object-glass is achromatic and composed of several lenses, one being of flint-glass and the other or others of crown-glass. See ACHROMATIC-LENS; LENS; TELESCOPE; EYE-GLASS; FIELD-GLASS.

Ob-ject'ive. (*Optics.*) That lens or combination of lenses in a microscope or telescope which brings the image of an object to a focus in order to be viewed through the eye-piece. The object-glass. Though acromatic lenses had been applied to telescopes by Dollond near the middle of the eighteenth century, yet in 1821, according to Biot, opticians regarded the construction of a good achromatic microscope as an impossibility.

In 1827 Professor Amici of Modena exhibited in England and Paris a horizontal microscope whose object-glass, of large aperture, was composed of three superimposed lenses. A microscope constructed by Chevalier, on Amici's plan, was awarded a silver medal.

The theory of the subject was about this time investigated by Sir John Herschel, Professor Airy, and others, and, acting on their theoretical views, Mr. Joseph Jackson Lister succeeded in effecting one of the greatest improvements in the manufacture of achromatic object-glasses by uniting a plano-convex flint lens with a convex lens by means of Canada balsam.

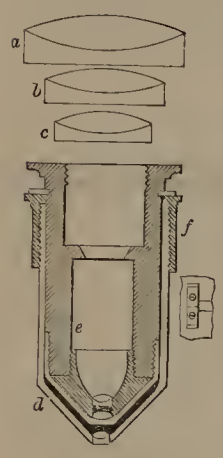
This diminishes by nearly one half the loss of light occasioned by reflection where the surfaces unite, and prevents the dampness or the formation of mold at the junction.

Mr. Ross, who subsequently devoted much time to the improvement of objectives, employs three lenses of this kind in order to correct the chromatic and spherical aberrations corresponding to varying

distances of the object, when it has to be viewed through an interposed plate of glass.

This is effected — supposing the posterior and middle combinations *a b* to have together an excess of negative aberration — by causing the anterior combination *c* to have an excess of positive aberration, and varying its distance from the other pairs.

Fig 3362.



Microscopic Objective.

For this purpose the anterior lens is set in the end of a tube *d* (as shown in the lower portion of the figure), which slides on a cylinder *c*, containing the remainder of the combination, and is caused to approach or recede therefrom by turning the screwed ring *f* or by simply sliding the tube on the interior cylinder, afterward clamping it.

An aperture is made in the tube *d*, through which is seen a mark engraved on the cylinder. A longer and shorter mark are engraved on the tube; and by bringing the former into coincidence with the mark on the cylinder the adjustment is perfected for an uncovered object. When the shorter mark is made to coincide with the mark on the cylinder, the proper adjustment is attained for correcting the aberration occasioned by glass $\frac{1}{100}$ of an inch in thickness.

Ob'ject-staff. (*Surveying.*) A staff the same hight as the level, forming a sight to be viewed from thence in determining levels.

A leveling staff consists of a graduated strip sliding in the dovetail groove of an upright bar, and provided with a cross-bar to whose crucial point the eye of the leveler is directed. The said bar is raised or lowered until it meets the level, and the hight is read on the staff. The sliding is for purposes of extension when the level is above the top of the main bar.

Ob-lique' Arch. One which conducts a road or railroad across a river, canal, etc., in an oblique direction; also called a *skew-arch.*

O'bo-e. (*Music.*) Or *hautboy.* A double-reed instrument with a compass of two octaves and a sixth, and written on the G clef. It has three pieces besides the reed-piece.

b. A reed-pipe stop of an organ, tuned in unison with *open-diapason*, and depending for the peculiar quality of its tone upon the shape of the tube through which the sound of the reed is transmitted. See STOP.

Ob-serv'a-to-ry. 1. A building provided with instruments for astronomical observations. See ASTRONOMICAL INSTRUMENTS; ARMILLARY-SPHERE, etc. See list under OPTICAL INSTRUMENTS.

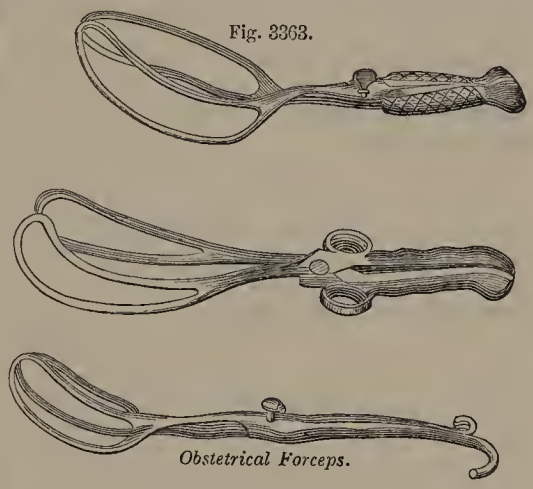
2. A chamber of observation at such an altitude as to look over adjacent objects and afford an extensive view. Used as a lookout-station for the fire-alarm service, for signaling, for meteorological observations, etc.

The iron observatory on the roof of the Equitable Life Insurance Company, on Broadway, New York, is 22 feet high above the roof of the building, which is 130 feet above the sidewalk. The probabilities of the weather are indicated by balls 12 feet in diameter, displayed upon two signal-staffs and visible from various points on Long Island Sound, Sandy Hook, and the inland waters of the Hudson and Harlem rivers. In the building is a large map, displaying the territory throughout which the service has its stations, reaching from Mexico to Canada, and from the Atlantic to the Pacific coast. The state of the weather is indicated by dials at each of these stations on the map, from which reports are received every five hours.

Ob-stet'ri-cal Chair. One capable of affording convenient position for the delivery of the child and access of the midwife.

Ob-stet'ri-cal For'ceps. (*Surgical.*) An accouchcur's instrument for grasping the head of the child and facilitating delivery. They are of varied shapes and construction, and have specific means,

Fig. 3363.



Obstetrical Forceps.

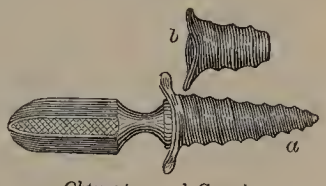
such as rings or hooks, to assist the hand when force is applied. The instrument was described by Butler in 1732.

Ob-stet'ri-cal In'stru-ments. (*Surgical.*) For assisting delivery, measuring the pelvic opening, etc. Among them may be enumerated the *cephalotribe, crochet, forceps, obstetrical supporter, pelvimeter, perforator, placenta-forceps,* and *hook.* Herophilus of Alexandria, of the school of Ptolemy, wrote on obstetrics.

Ob-stet'ri-cal Sup-port'er. One having braces around the hips and knees, and affording holds for the hands, to assist the muscular exertions of the mother during parturition.

Ob'tu-ra'tor. (*Surgical.*) An instrument for distending an opening, as in the example, which shows a pointed screw-shaped appliance, used in cases of lithotomy. The instrument shown at *a* is thrust through the portion *b*, and together with it is driven, by pressure and rotation, through the opening made by the gorget, distending it. The *obturator a* is then withdrawn by backward rotation, leaving the *canula b* in situ, to form a channel through which the *lithontriptor* or *lithoclast* is introduced to crush the stone.

Fig. 3364.



Obturator and Canula.

Ob'verse. The face of a coin or medal. The other side is the *reverse.*

An *obverse* tool has the smaller end toward the haft or stock.

Oc'ta-chord. (*Music.*) A musical instrument having 8 strings.

Oc'tant. (*Optics.*) An instrument for measuring angles, resembling a quadrant or sextant in principle, but having an arc of 45°, the eighth part of a circle. See SEXTANT.

Oc'tave Flute. (*Music.*) A flute having a pitch

an octave higher than the ordinary flute. A *piccolo*. See MUSICAL INSTRUMENTS, Fig. 3263.

Oc-ta'vo. A sheet printed with 8 pages on each side. 8vo.

Oc'to-bass. (*Music.*) An instrument of the viol family, the low octave of the violoncello. It has three strings tuned in fifth and fourth. It has movable keys to press the strings upon frets of the neck. The keys are moved by levers governed by the left hand, and by pedal keys on which the foot of the player acts. Its compass is one octave and a fifth.

Oc-to-dec'i-mo. A sheet printed to make 18 pages on a side. 18mo.

Oc'to-style. (*Architecture.*) Having eight pillars on a front.

Oc'u-lar; Oc'u-laire. The eye-piece of a telescope or microscope.

Odd-side. (*Founding.*) When many castings are required from one pattern, or from a number of patterns, molded in the same flask, the *false-part* is prepared with care in an odd-flask, and is preserved indefinitely. By the use of a good *odd-part*, much time is saved in making the parting.

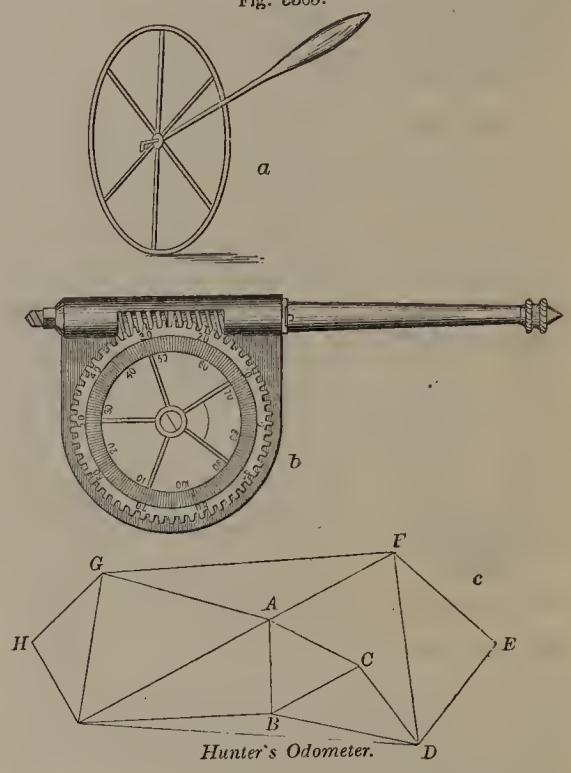
O-dom'e-ter. "The machine for *measuring distances when traveling*," Vitruvius says, "was discovered by the ancients and is yet found very useful." (50 B. C.) When adapted for a chariot or traveling carriage, the wheels were made of such a diameter that every revolution would advance the vehicle 12½ feet. Thus 400 revolutions passed over 5,000 feet, or a Roman mile. The diameter of the wheels was therefore nearly 4 feet. A drum-wheel was fixed to the inner side of the hub of the wheel, and had one small projecting tooth, which, at each revolution, turned one tooth of a cog-wheel journaled in a box above and having 400 teeth. This cog-wheel had a single projecting tooth which acted on a third wheel which had holes equal in number to the number of miles in an ordinary day's journey.

In each hole of the third wheel was placed a small ball, and these were brought consecutively to an opening in the case through which they dropped into a metallic vase; indicating audibly the transit of one mile at each sound of the ball. By the numerical proportion of the gearing, a ball was dropped at every 400th revolution of the carriage-wheel to whose hub the first drum-wheel was attached. At the end of the journey the number of balls indicated the number of miles traveled.

Vitruvius, in his tenth book, describes a machine of this kind for a carriage, and which, in his opinion, would answer for a ship. We are told by Capitolinus, in his life of the Emperor Pertinax, that among the effects sold, of the Emperor Commodus, there were carriages which "measured the road and pointed out the hours" (et alia iter metientia, horasque monstrantia).

Hunter's odometer *a*, the working parts shown enlarged at *b*, has a light wheel, 6 feet in circumference. This is driven by a handle grasped by the pedestrian. On the axis of the wheel is a worm, which engages two cog-wheels which have 100 and 101 teeth respectively. 100 revolutions of the axis will turn each wheel 100 teeth, so that the zeros of the wheels will be one degree of the scale apart. Another 100 revolutions of the wheel will make their zeros 2 divisions distant, and so on. In the cut the zeros are 78 divisions apart, and the upper index points to 26 of the scale. As each revolution of the wheel is 2 yards, and the revolution of the first cog-wheel is $2 \times 100 = 200$, each degree of variation is equal to 200 yards. $78 \times 200 + [26 \times 2] =$ 15,652 yards.

Fig. 3365.



Hunter's Odometer.

The range of the instrument is when the zero of the second cog-wheel has again reached the zero of the first, which shows $101 \times 100 = 10{,}100$ revolutions of the axis, which being 6 feet, the range is found to be $10{,}100 \times 6 = 60{,}600$ feet = nearly 11½ miles.

The odometer is employed in mapping districts of country, filling details of roads and lanes in triangulations. One form used by the United States Coast Survey is a wheel 2 feet 7½ inches in diameter, 8 feet 3 inches in circumference, traversing one rod in 2 revolutions. The index in the box points to miles and rods traversed.

Odometers are sometimes used in hacks and carriages for casual hire, to determine the distance.

Fernel, physician to Catharine de Medici, Queen of France, measured with an instrument of this kind, in 1550, a degree of the meridian between Paris and Amiens, and found it to be 303 toises less than Picard afterward found it to be. It is supposed that the revolutions of the wheel were noted by striking on a bell.

The measurement of a degree of latitude has been made and recorded not less than fourteen times in the last 1,000 years. Its length varies in different countries, as the facts show and theory had supposed.

Eratosthenes, B. C. 276, attempted the measurement of the size of the earth, by ascertaining the distance between Alexandria and Syene, the differences of latitude between which places he had found to be $\frac{1}{50}$ of the earth's circumference.

Some previous measurements are mentioned under ARMIL (which see). Hipparchus of Nicæea in Bithynia, 162 B. C., laid down a map by the determination of the latitude and longitude of places. A degree was measured on the shores of the Red Sea by the Khalif al Maimoun, the son of Haroun al Rasehid, about A. D. 820.

The exact determination of the length of a degree was considered of so much importance that, in 1735, the Academy of Sciences of Paris dispatched two commissions, one to Peru, the other to Lapland.

The latter party accomplished their mission and returned in 16 months; the former party, after contending with great hardships for 10 years, accomplished their mission, as Frenchmen in pursuit of an idea will do, if anybody can.

Since the work of the French Academicians, measurements have been taken in India, France, England, Hanover, Lithuania, and Sweden. One curious discovery resulted, as stated by Sir John Herschel: —

"The earth is not exactly an ellipsoid of revolution. The equator itself is slightly elliptic, the longer and shorter diameters being respectively 41,852,864 and 41,843,096 feet. The ellipticity of the equatorial circumference is therefore $\frac{1}{1283}$, and the excess of its longer over its shorter diameter 2 miles."

The polar axis is 41,707,796 feet in length.

It is many years since better devices superseded the old plan of measuring the surface, as adopted by Fernel in 1550. Picard's more correct estimate was made in the next century, but it is not recorded whether he made it by a direct measurement by rods and chains, or by a measured base-line and subsequent triangulation.

The base-line on which the Ordnance Survey, the triangulation of Britain, is founded, is 5.2 miles nearly. It is said that the greatest *possible* error in the length of this line is 2 inches. See SURVEYORS'-CHAIN.

The diagram *c*, Fig. 3365, will explain.

"A level piece of ground is selected near the meridional arc proposed to be measured. On this a straight line *A B* is traced, and its length accurately found by the application of rods of metal, wood, or glass. The ground adjoining the arc to be measured is then divided into triangles by means of signals *C, D, E, F, G, H, K*, erected at convenient distances or on remarkable points of the country; and the angles which the signals make with each other determined by a theodolite or similar instrument. The sides *A C, B C*, are then deduced from the measured base *A B*, and thence successively the sides of the other triangles. In this manner the whole distance between the stations which form the terminal points of the arc is determined by a series of trigonometrical calculations. The reductions for the differences in the levels of the respective stations must next be applied, and also for their altitude above the level of the sea."— BRANDE.

The following table shows the length of a degree of latitude at every tenth degree: —

Latitude.	Length of degree in English feet.	Latitude.	Length of degree in English feet.
0	362,734	50	334,862
10	362,843	60	335,454
20	363.158	70	335,937
30	363,641	80	336,252
40	364,233	90	366,331

The length of the degrees of longitude at every tenth degree is as follows: —

Latitude.	Length of degree of longitude in English feet.	Latitude.	Length of degree of longitude in English feet.
0	355,152	50	235,171
10	350,640	60	183,029
20	343,263	70	125,254
30	316,493	80	63,612
40	280,106	90	0

Odometers were possessed by Augustus, the Elector of Saxony, A. D. 1553 – 86, and the Emperor Rodolphus II. 1576 – 1612. In the eighteenth century they became common, and descriptions are found in scientific reports and works of that date.

Hohlfield, born at Hennerndorf, in Saxony, in 1711, seems to have much improved the instrument.

A new French instrument, termed a "compteur mécanique," or calculating-machine, not only reckons the distance traversed, but indicates as well the exact sum of money due to the driver. Two dials are fixed on the back of the driving-seat; one contains a clock, while on the other the distance traveled is indicated by a hand acted on by the wheels; it is entirely beyond the control either of cabby or his "fare." The apparatus is put in and out of gear by the lowering and raising of a lever bearing the word "libre," which is only visible when the cab is empty, and the "compteur" consequently unemployed. There is no danger of the driver omitting to lower this lever as soon as he is hired, it being evidently his interest to have the greatest possible distance paid for; while, on the other hand, it would be useless for him to try to make a fictitious fare by driving about with his "compteur" in motion, for a card in the interior of the machine registers the distance traversed during the day, and the money to be accounted for to the cab-owner. The great difficulty has hitherto been to find a means of marking the time spent in visits, shopping, blocks in the streets, etc., when the wheels and the tell-tale are necessarily at a standstill. M. Bruet, the inventor of the new register, has now overcome this difficulty by a contrivance, by means of which, as soon as the wheels cease to act on the indicator, the clock which forms part of the machine keeps the tell-tale hand moving at a rate which credits the driver with eight kilometers (about five miles) an hour, or two francs, according to the Parisian tariff.

Table of Lengths of Foreign Road Measures.

Place.	Measure.	U. S. Yards.
Arabia	Mile	2,146
Austria	Meile (post)	8 297
Baden	Stunden	4,860
Belgium	Kilometre	1,093.63
Belgium	Meile	2,132
Bengal	Coss	2,000
Birmah	Dain	4,277
Bohemia	League (16 to 1°)	7,587
Brazil	League (18 to 1°)	6,750
Bremen	Meile	6,865
Brunswick	Meile	11,816
Calcutta	Coss	2,160
Ceylon	Mile	1,760
China	Li	608.5
Denmark	Miil	8,258
Dresden	Post-meile	7,432
Egypt	Feddau	1.47
England	Mile	1,760
Flanders	Mijle	1,093.63
Florence	Miglio	1,809
France*	Kilometre	1,093.6
Genoa	Mile (post)	8,527
Germany	Mile (15 to 1°)	8,101
Greece	Stadium	1,093.33
Guinea	Jackfan	4
Hamburg	Meile	8,238
Hanover	Meile	8,114
Hungary	Meile	9,189
India	Wussa	24.89
Italy	Mile	2,025
Japan	Ink	2.038
Leghorn	Miglio	1,809
Leipsic	Meile (post)	7,432
Lithuania	Meile	9,781
Malta	Canna	2.29
Mecklenburg	Meile	8,238
Mexico	Legua	4,638
Milan	Miglio	1,093.63
Mocha	Mile	2,146
Naples	Miglio	2,025
Netherlands	Mijle	1,093.63

* 1 60931 miles = 1 kilometre.

Place.	Measure.	U. S. Yards.
Norway	Mile	12,182
Persia	Parasang	6,076
Poland	Mile (long)	8,100
Portugal	Mitha	2,250
Portugal	Vara	3.609
Prussia	Mile (post)	8,238
Rome	Kilometre	1,093.63
Rome	Mile	2,025
Russia	Verst	1,166.7
Russia	Sashine	2.33
Sardinia	Miglio	2,435
Saxony	Meile (post)	7,432
Siam	Roënung	4,333
Spain	League legal	4,633
Spain	League, common	6,026.24
Spain	Milla	1,522
Sweden	Mile	11,660
Switzerland	Meile	8,548
Turkey	Berri	1,828
Tuscany	Miglio	1,809
Venice	Miglio	1,900

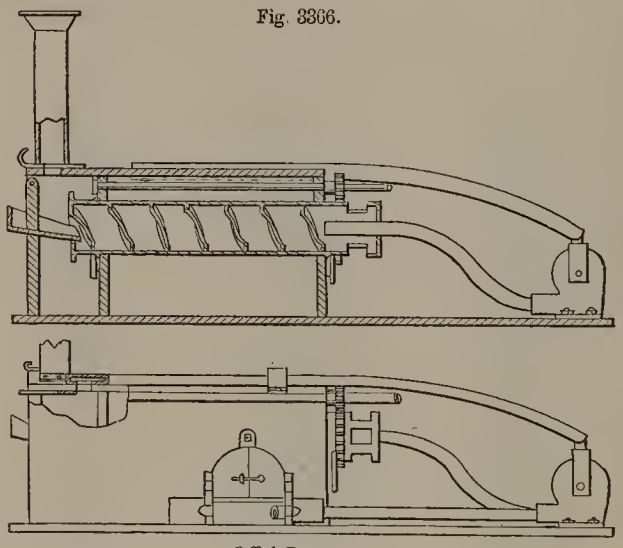
O-don'ta-gra. A form of dental forceps.

O-don'to-graph. (*Gearing.*) An instrument for marking or laying off the teeth of gear-wheels; invented by Professor Willis. It consists of a graduated card or thin board, having one edge beveled at an angle of 75°. This is applied to the radii terminating at the centers of the interspaces between the teeth and the centers from which the curves forming their flanks and faces are laid off from tables printed on the instrument.

Œ-nom'e-ter. A hydrometer adapted to determine the strength of wines.

Of'fal-dry'er. The bones, offal, manure, or other material to be dried, being passed into the rotary cylinder, are caused to traverse the same throughout

Fig. 3366.



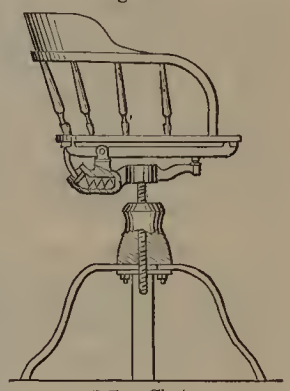
Offal-Dryer.

and discharged at the end adjacent to the fan. The hot fan-blast, together with the steam and offensive gases, may be allowed to pass off directly through the chimney, but by closing a damper they may be conducted to the fan and driven into the ash-pit of the furnace.

Off-cut. That part of a sheet which is cut off before folding, and then placed within the other previously folded portion. This occurs in some modes of imposing.

Of'fice-chair. Preferably a chair which may be raised or lowered by a screw, on which it may be rotated, and also admitting of being tipped back. Casters complete the list of adaptabilities, and leave but strength and sumptuous upholstery to be desired.

Fig. 3367.



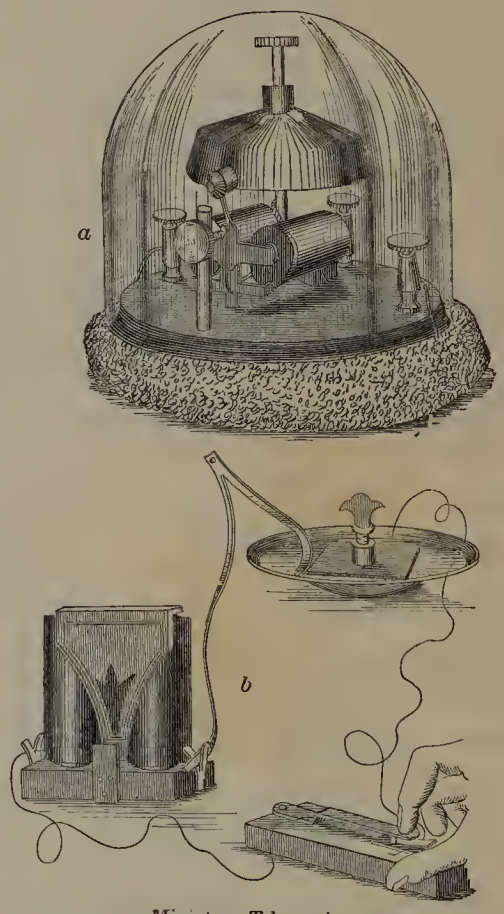
Office-Chair.

Of'fice-tel'e-graph. A form of miniature telegraph for signaling from one room to another in a building.

It consists of a little electric bell, shown at *a*, Fig. 3368; these instruments are placed upon the desks in the various departments of an establishment, and from them wires extend to the desks of the managers, on which buttons are fixed, which connect with the wires. When the manager wishes to communicate with any particular person on the premises, he touches the button corresponding to the wire leading to the bell where the individual is at work. The touch sounds the bell, and, as a variety of signals may be sent, one bell may serve to signalize different persons who are within its hearing. This instrument, with bell, battery, and some yards of wire, is made for $ 5.

Another form of telegraph, shown at *b*, Fig. 3368, is used for purposes of experiment and instruction as well as communicating messages, and consists of an electro-magnet, sounding armature, a galvanic bat-

Fig. 3368.



Miniature Telegraph.

tery, telegraph-key, connecting-wires, and chemicals, all complete for working. The battery is composed

of two small plates, one of lead, one of zinc, the latter covered with paper as a septum, both plates set in a common saucer, in water in which a few grains of sulphate of copper are dissolved.

Off'set. (*Masonry.*) *a.* A ledge on the face of a wall at the point where its thickness is decreased.

b. A break or recess in a front, setting back from the general surface.

O-gee'. 1. A wave-like molding, having an inner and outer curve, like the letter S. Swelling in the upper part and hollow below, is the *cyma-reversa;* hollow in the upper part and swelling below, is the *cyma-recta.* (See MOLDING.) In its peculiar forms, or with other members of peculiar character, the ogee is known as *rampant ogee, quirked ogee,* etc.

2. A pointed arch, the sides of which are each formed of two contrasted curves. See ARCH.

O-gee'-plane. A joiner's plane for working ogee-moldings.

O'give. Arches or branches of a Gothic vault, which, instead of being circular, pass diagonally from one angle to another, and form a cross with the other arches which make the sides of the squares, whereof the ogives are diagonals. The middle, when the ogives cut or cross each other, is called the key, sometimes carved in the form of a rose. The members or moldings of the ogives are called nerves, branches, or veins; and the arches which separate the ogives, double arches.

Oil-bag. A sack of horsehair or cocoa-nut fiber, used in pressing oleine from the stearine in a press.

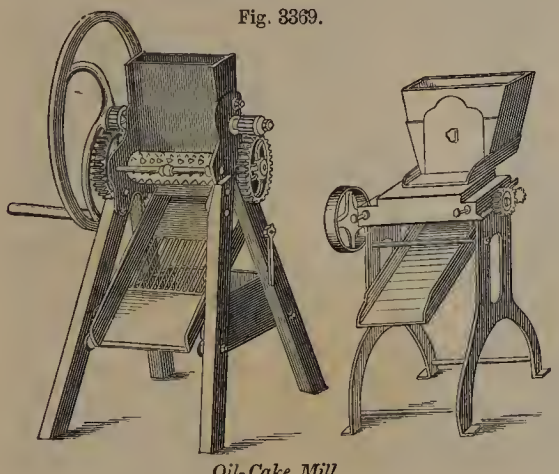
Oil-box. A box containing a supply of oil for a journal, and feeding it by means of a wick or other device. An *oil-cup.*

Oil-cab'i-net. A box or reservoir in which oil is kept in store, either by a retail dealer or in the storeroom of a factory or machine-shop. Cans or oilers are filled from the cabinet by means of a small pump.

Oil-cake. The marc or refuse after oil is pressed from flax, rape, or hemp seed; or from cocoa-nut pulp. Used for cattle-feed or manure.

Oil-cake Mill. A machine to crumble flaxseed oil-cake as a food for stock. The illustration shows

Fig. 3369.



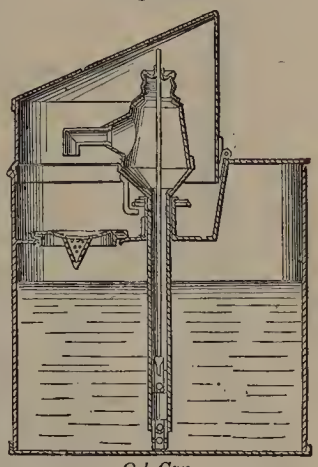
Oil-Cake Mill.

a machine with a pair of studded rollers which may be set at such a distance apart as shall give the result required. The machine may be set to nine different grades of fineness without affecting the mesh of the gearing.

The other illustration is a machine to be run by band and pulley.

Oil-can. 1. One for storage of oil, from which it is withdrawn for sale or use, as the case may be. In the example, the oil-can from which the oiler is filled is placed in the tray, whose floor has an opening for the stock of the pump, which is steadied by a sleeve, and held down by a hook, which engages a flange on the sleeve.

Fig. 3370.

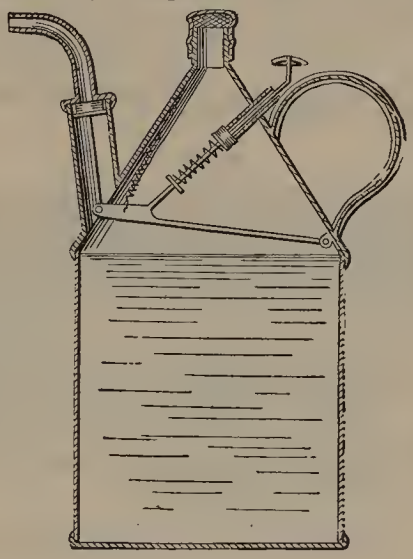


Oil-Can.

2. One for holding oil for supplying lamps, oil-cups, or journals, as in the example. Fig. 3371, in which the spout and vent-hole have stoppers projected against their outlets by the spiral springs and pivoted bar. The sliding trigger opens both at once.

3. An *oiler* for lubricating bearings; one on a larger scale is shown in Fig. 3372, in which the tubular handle has a plunger, which is depressed by

Fig. 3371.



Oil-Can.

the thumb to force the oil from the nozzle. The plunger is connected to the stem of a valve near the point of the nozzle; the valve is opened simultaneously with the depression of the plunger.

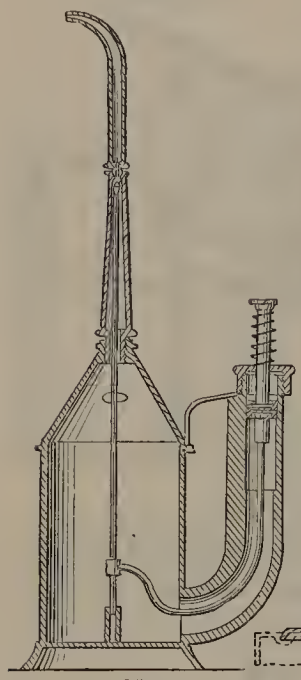
For the smaller kinds of oilers, see OILER.

Another kind of oil-can is that in which oil in measured quantities is shipped and sold. The ingenuity in this case consists in the nozzle, in the means of making and fastening the joints, so as to be economical of material, ready in construction, and convenient in use. See also PAINT-CAN.

Oil-car. Oil-cars may be seen upon our railways carrying large cylindrical vessels resembling the Western two-flue steamboat-boiler, and with a dome at the midlength. Another form of car-tank is a frusto-conical vat, like a mash-tun; two or three of which are accommodated on a platform-car. Another form is like that in the figure, in which oblong square tanks are built so as to occupy the carbed, upon which they are fastened by cleats and stay-rods. The tanks are made of matched planks bolted together.

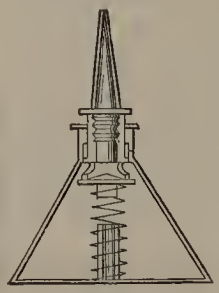
See OIL-TANK.

Fig. 3372.



Oiling-Can.

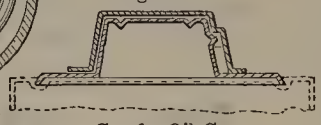
Fig. 3373.



Oiler.

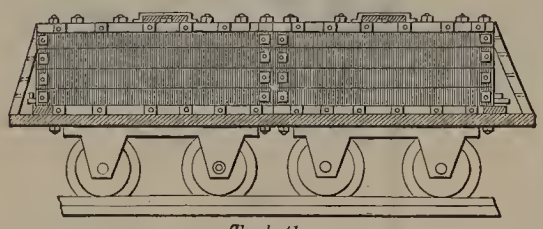
Oil-car'ry-ing Ves'sel. One having built-in tanks in the hold to hold oil in bulk. It has conveniences for loading and discharge, and also for allowing expansion and contraction of the oil without overflow of the liquid or collapse of the tank.

Fig. 3374.



Cap for Oil-Can.

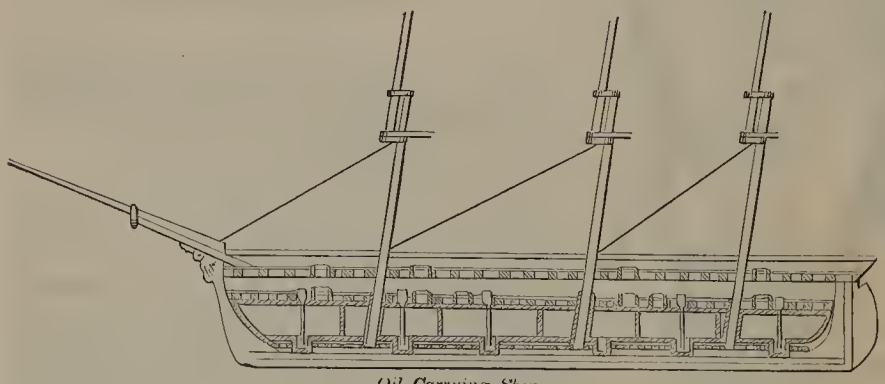
Fig. 3375.



Tank-Car.

Molasses is also carried in bulk from the West Indies to Portland and elsewhere.

Fig. 3376.



Oil-Carrying Ship.

Oil-cel'lar. An oil-reservoir in the bottom of a journal-box.

Oil-cloth. A tarpaulin.

Painted canvas for floor-covering. The latter description is prepared from cloth especially woven for the purpose, frequently of great width, and covered on each side by a peculiar series of processes, with paint. Figures or patterns in oil-colors are afterward printed on one side by means of wooden blocks. See FLOOR-CLOTH.

Floor oil-cloth is manufactured from jute, made principally at Dundee, Scotland. This is woven into widths of frequently from 18 to 24 feet, in looms at which two men, one on each side, are employed in throwing the shuttle. The length of the warp often exceeds 100 yards. The pieces are cut to the desired size, and these smaller pieces are stretched upon upright wooden frames, each of which has a series of scaffolds, reached by a ladder at one end of the frame.

When the canvas is perfectly stretched, a weak solution of size is laid on with a brush, and while yet damp it is well rubbed with pumice-stone, filling up the interstices between the threads and preventing the paint from penetrating too far, so as to render the fabric brittle. When this is dry the paint, which is of a very thick consistence, containing little or no spirits of turpentine, is applied in dabs with a short thick brush. These are then partially scraped off with a long elastic trowel, the paint at the same time worked into the cloth, leaving a level surface. This is allowed to dry from 10 to 14 days, when a second and sometimes a third coat of thinner paint is smoothly applied with the trowel, finishing the under side. In the mean time the other side, which is to be finished, is similarly sized and pumiced and a coat laid on with the trowel, and carefully pumiced so as to remove all knots or inequalities from the surface. To this succeed two more layers, each laid on with the trowel and rubbed with pumice, over which a fourth coat, called the *brush color*, forming the ground of the future pattern, is thinly laid on with a brush.

The whole series of operations occupies from two to three months, and when the final coat is dry the cloth is removed to the printing-room. The printing is performed on a long flat table, by means of engraved wooden blocks, the cloth being drawn along the table as required.

One block is required for each color forming the pattern.

The process is thus performed: A number of cushions, one for each color, is placed upon a table, and by the side of each cushion is a pot of color. The cushions consist of a pad of flannel covered with smooth floor-cloth. A boy, called the *tierer* or *tcarer*, takes up a portion of color on a brush and spreads it evenly over the cushion. The cloth being spread upon the table, its upper surface is slightly roughened with a steel scraper and afterward with a brush, to enable it better to take the color. The printers, each of whom is provided with a block for containing a separate color, follow one another in succession; each charging his block by pressing it down on the cushion. The first takes it to the cloth and, applying it to his part of the pattern, hits it several taps with the handle of a heavy hammer, leaving an impression in one color only; the second, third, etc., follow, each printing in a similar way his own portion of the pattern in a different color from his predecessor. As the work proceeds the cloth is turned over and descends, through an

opening in the floor, to the drying-room, where it sometimes remains several months.

Oil-cock. A faucet admitting oil from an oil-cup to the journal. See OIL-CUP; LUBRICATOR.

Oil-cup. When portable, for oiling machinery, they are considered as OILERS (which see). When attached to a boxing, or otherwise permanent, and devoted to a special bearing, valve, piston, etc., they are considered as LUBRICATORS (which see). Devices for holding oil, in which capacity and storage are elements in their usefulness, are considered under OIL-CAN; OIL-TANK; OIL-CAR.

Oiled Leath'er. Leather dressed with oil; as CHAMOIS-LEATHER (which see).

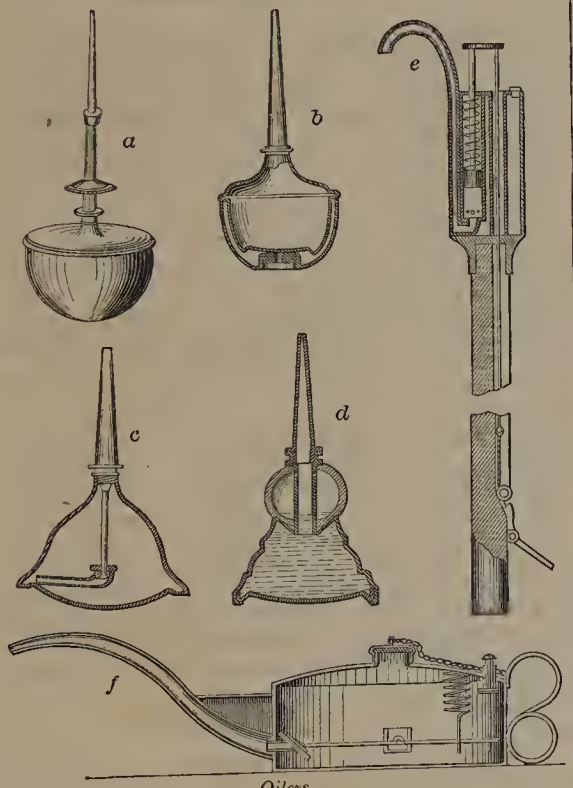
Oiled Pa'per. Transparent paper used for tracing. See TRACING-PAPER.

Oiled Silk. (*Fabric.*) Silk which has been treated with a boiled oil, so as to render it water and perspiration proof. Used as sweat-pads, as a lining in hats and bonnets to resist the perspiration, and over wet dressings of wounds to prevent evaporation.

Oil'er. A can for applying oil to a journal. From the numerous forms the following may be selected: —

a is Olmstead's oiler, made of thin sheet-metal,

Fig. 3377.



Oilers.

the bottom of the bulb being weighted so that it always stands upright.

b is Broughton's oiler, having an outer shell, an internal reservoir of elastic material, and an opening in the bottom for a thumb-piece, by which the reservoir is compressed to discharge oil.

c has a swiveled tube attached by an elbow to the discharge-tube, and which reaches the oil collected at the lower portion of the can when tilted.

d has a transparent chamber between the nozzle and the reservoir.

King's oiler, *e*, is for reaching shafting in an elevated position; the oiler is placed on the end of a handle, and the oil ejected at the goose-neck by a plunger actuated by a wire and a trigger-lever on the handle.

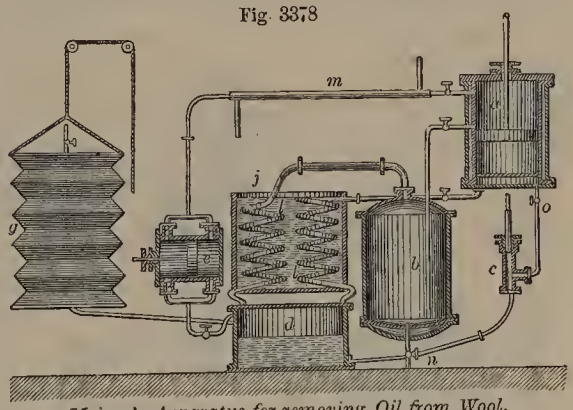
f is an oiler for large machinery, steamships, etc. It is air-tight, and will not discharge when upset, nor when tilted, until the air-valve is pressed by the thumb, although the spout is always full.

An early form of this useful little appliance is to be seen in the British Museum. It is a small horn with a plate on the end, and a nozzle through which the oil exuded. Whether the flat end at the base of the horn is elastic, so as to assist in ejecting the oil, does not appear. It was found at Thebes by Mr. Burton, associated in a basket with several other carpenter's tools, all of which are in the same magnificent collection. The other tools are chisels, drills, drill-bow, saws, mallet, and nail-bag. See cut under MALLET.

Oil-ex-tract'ing Ap'pa-ra'tus. Other than the grinding-mill and press, chemical means have been used for extracting oils from seeds, nuts, grain, fruit; also oil from wool. The seeds or nuts are crushed or ground, immersed in bisulphide of carbon, which extracts the oil and resin they contain, but leaves the substance otherwise unaltered. The solution is then removed, the bisulphide distilled off, leaving the oil, like the raw oils extracted by pressure, contaminated to some degree with resinous and coloring matters, which are removed by a second process of refining.

This process was invented by Moison of Mouy, in France, and used by him in cleansing wool from the

Fig. 3378



Moison's Apparatus for removing Oil from Wool.

suint, as also from the grease and tar with which the sheep had been treated or marked. It was afterward adopted to separate oils, fats, and resins from the substances with which they are combined, and for supplementing the mechanical processes by operating upon oil-cake, the marc of olives, etc.

In Moison's process the wool to be subjected to treatment is introduced into a cast-iron cylinder *a*, surrounded by a jacket into which steam may be conducted when it is necessary to raise the temperature. 214 pounds of wool are placed in this cylinder at once. Within the cylinder is a false bottom perforated with numerous holes, with a small free space beneath it. Upon the top of the wool is placed a circular follower or compressor, fitting the interior of the cylinder, and perforated also with holes like the false bottom. Three rods connected with this follower pass through stuffing-boxes in the lid, and may be driven downward by means of fixed screw-nuts, the rods having screw-threads cut upon their prolongations above the cylinder to compress the wool to about one half its original volume. The lid being luted on, bisulphide is introduced by

pump *c* from reservoir *d*, forced through the layer of wool and overflows into the still *b*, where it is volatilized by steam in the jacket. The vapor of the bisulphide is conducted from the still to the refrigerator *j*, where it is condensed in the spirals *l l* and returned to the reservoir *d*. When no more oil comes over, the pump is stopped, the vessel *a* discharged by the stop-cock *o* leading to reservoir *d*, and the oil remaining in the still from the distillation of the bisulphide is withdrawn at the stop-cock *n*. The proper changes of stop-cocks being made, the air-pump *e* is brought into requisition to fill the upper portion of chamber *a* and drive the bisulphide downward out of the wool. To make this more complete, at the latter stages, the air from pump *e* is led through the steam-jacketed chamber *m* to enable it to volatilize the bisulphide of carbon in *a*. *g* is a gas-holder to hold any superfluous gas, to keep the capacity adjusted to the varying volume of the contents. The boiling-point of the bisulphide of carbon is 118° Fah.

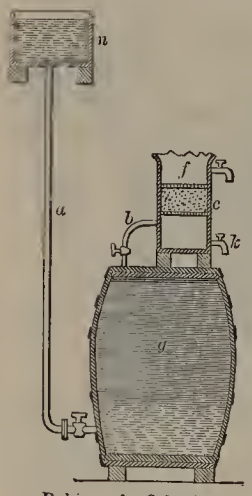
The process is adapted to dissolving the oils contained in the strippings of machine-cards in factories, and saving the waste from the axles of car-boxes, the journal-boxes of machinery. See also Sim's and Hutchinson's processes and machines, patented 1869, 1870, 1871. These are also particularly intended for extracting fusel-oil from grain.

Oil-fil'ter. Robinson's oil-filter acts by the upward pressure of a column of water below the oil.

The operation is as follows: —

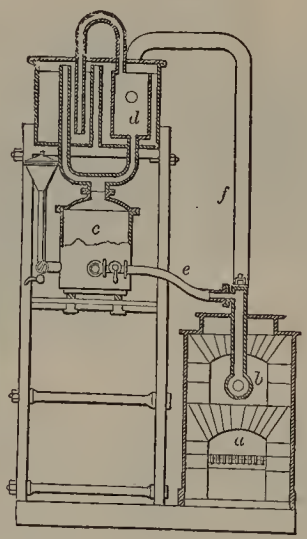
The butt *g* of oil being placed on a stillion, communication is made with its lower portion by means

Fig. 3379.

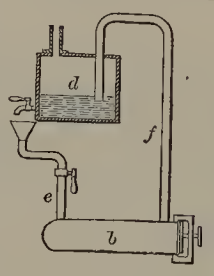


Robinson's Oil-Filter.

Fig. 3380.



of a pipe *a* leading from a cistern of water *n*. As the water flows into the butt, it displaces the oil, which passes by pipe *b* to the lower chamber of the filter which stands on the head of the butt. It thence passes through the perforated plate, a body of charcoal *c*, and a second perforated plate, to the upper chamber *f*, from whence it is discharged by the faucet. Impurities in the lower part of the filter are discharged by the faucet *k*.



Oil-Gas Apparatus.

Oil-gas. Gas was distilled from oil by Dr. Henry in 1805; and from refuse oily and fatty matters by Taylor, and patented in 1815.

The apparatus for the distillation of oil to obtain a permanent gas consists of a furnace *a* and retort *b*, the latter being charged with coke or brick, on whose heated surfaces the oil drips continuously from a reservoir.

The retort is a cylindrical vessel with a luted cover, and the oil is supplied in graduated quantities through a pipe *e* from a copper reservoir *c*. The gas evolved passes by an eduction-pipe *f* to a cistern, where, after passing through water, it is led by a pipe to the holder. The reservoir *c* also serves to receive the oil which may condense in the gas-holder *d* above. The double walls of the gas-holder contain water to cool the gaseous products of distillation.

There are many minor variations of the apparatus, but it is a simple process, requiring an occasional change of the coke.

Oil-gild'ing. A process of gilding in which the gold-leaf is laid on a surface prepared by a *priming* of whiting and size; several coats of *clear cole*, or transparent size; and an upper surface of *oil-gold size*, made of boiled linseed-oil and ochre, laid on by a brush. See GILDING.

Oil'ing. (*Wool.*) A stage in the manufacture of wool, which is first *opened* by the *devil* or *willy*, and then *burred* in a machine to remove impurities. The *oiling* follows, to prevent the fibers from becoming felted in the subsequent *scribbling* and *carding*.

Oil-leath'er. (*Leather.*) Oil-leather is prepared by currying hides in oil. Neat's-foot oil is used, but fish-oil is more commonly employed; to this the French add potassa. It is both more economical and more effective. The hides are somewhat moist, that the oily matters may be gradually and thoroughly absorbed.

"A coating of oil is uniformly spread over the grain and flesh sides, after which the hides are hung up to dry, the direct rays of the sun or too violent a draft being guarded against. In summer time the drying is effected in 12 hours, in winter it may extend to 3 or 4 days. When dry, the hides are again fulled, oiled, and dried. This is repeated. Finally, the grain-side is cleansed by rubbing it well with a brush and weak potassa lye. The coloring of the grain or flesh side, as the case may be, follows these operations, and is effected by a dye." As, for instance, the solution of sulphate of iron, which unites with the gallic acid of the tan to produce a black dye. "After receiving one coat the leather is pommeled crosswise; another layer of blacking is applied; dried, pommeled, or stretched, according as it is deemed necessary; rubbed over with a cork pommel to give it a smooth surface, and finished by giving a light coat of oil on the hair-side." — MUSPRATT.

Oil-mill. There are several varieties of oil-mills: —

1. With cylindrical rollers rotating on parallel axes and with their peripheries in contact, or nearly so. These rollers are of cast-iron, turned truly in a lathe, and with gudgeons running in brass boxes in the cheeks of the frame. A difference of speed adds a certain grinding action to the mere forcible pressure, and may be attained in one of two ways: —

a. By giving an equal axial speed to the rollers, which have varying diameters; or

b. By driving rollers of equal diameter at varying axial speeds.

The variation in speed is best attained by an unequal number of teeth in the driving-pinions.

2. Another form of oil-mill is the ancient *Phœnician* or *Chilian mill*, which has two rollers journaled to a horizontal shaft projecting from a vertical and

rotating post, the peripheries of the rollers traversing on a flat circular bed.

This is a grinding and crushing action, inasmuch as the flat face of the stone is parallel to the axis, and the portions of the face farthest from the vertical axis of revolution tend to traverse farther than the portions nearest to the said axis, so that, a compromise being effected, one portion or the extremes of each are obliged to rub as they rotate. The same principle is involved in this that is found in the traversing of a curve by the pair of wheels of a railway car. The wheel traversing the outer rail of the curve has farther to go than the inner wheel, and the latter will compel the outer one to slip back or the outer one will slip the inner wheel forward, — if the rails be in a horizontal plane. This brings a torsion on the axle, and is a fruitful cause of accidents; but is a valuable feature in the Chilian mill, so called, as it tends to mix and macerate the material, instead of packing it into a cake. See CHILIAN MILL.

The rolling-mill is sometimes employed as a preliminary, in the case of seeds with compact and slippery rind, such as those of flax and rape. Such seeds may then be subjected to the first expression, for the first quality of *cold-drawn oil*.

The press for the expression of the oil may be worked by screw, wedge, or hydrostatic power. See HYDROSTATIC PRESS; SCREW-PRESS; WEDGE-PRESS.

The magma after the first expression may be reground in the *Chilian mill*, or subjected to vertical stamps, which mash the seeds in mortars placed beneath them. See STAMPING-MILL.

The first and second expressions of oil having been obtained cold, the magma is now subjected to heat in a pan, being constantly stirred by a machine-driven spatula. It is then ready for the third pressure, which is final, if the resulting cake is to be used for cattle-feed. If, however, the last atom of grease is to be obtained, the magma is boiled, and the result of the fourth expression is so complete that the cake has no value except as manure.

In this recitation of processes it must not be overlooked that the repetitive method is only used where the various grades are required, and the system varies with different seeds and nuts. The resulting oils derived from the pressure of different vegetable productions bear different values, and the plans adopted vary to some extent with the kind.

It is common in the case of flaxseed, which leads the list in point of importance, to grind and heat the seed and then subject it to the hydrostatic press, securing all the oil at a single or once-repeated pressure.

Castor-oil is valued more highly, and is cold drawn, or should be.

A list of the more important expressed oils is given, with some particulars as to each.

Variety.	Quality.	Specific Gravity.	Oil per cent. Ure *et al.*
Flax	Drying	0.9347	11 - 22
Poppy	D.	0.9243	56 - 63
Hemp	D.	0.9276	20
Sesamum	Greasy		50
Olive	G.	0 9176	
Almond	G.	0.9180	50
Cucumber	D.	0.9231	25
Beech	G.	0.9225	16
Mustard	G.	0.9160	30
Sunflower	D.	0.9262	15
Rape	G.	0 9136	33
Castor	D.	0.9611	62
Tobacco	D.	0.9232	
Plum-kernel	G.	0.9127	33
Grape-seed	D.	0.9202	20
Cocoa-nut	G.		
Palm	G.	0.968	
Camelina	D.	0.9252	28
Cotton-seed	D.		12
Colza	G.	0.9136	40
Radish-seed	G.	0.9187	50
Apple-seed	G.		
Horse-chestnut	G.	0.927	10
Pine-top	D.	0.9285	
Walnut	D.	0.9260	50

OILS, WAX, ETC.

Common Name.	Botanical Name.	Native Place, or where chiefly grown.	Qualities, Uses, etc.
Almond	Amygdalus Communis	S. Europe, etc	One of the finest of fixed oils; used chiefly in medicine.
Argan	Argania syderoxylon	Morocco	Obtained from the kernels of the fruit; resembles olive-oil.
Beech	Fagus sylvatica	Europe	The mast affords an oil used for burning and in cooking.
Ben	Moringa pterygosperma	India and Arabia.	Oil from the seeds of the horse-radish tree. Used in perfumery and by watchmakers on account of its not readily freezing.
Birch	Betula alba	Europe	Bark affords an oil by distillation. Used in the prepara-
Brazil-nut	Bertholletia excelsa	Brazil	Used for burning in lamps. [tion of Russia leather.
Butters			Term applied to the semi-solid greasy substances that exude from trees, as shea-butter, butter and tallow tree, vegetable butter, etc. Used for cooking and burning.
Cacao	Theobroma cacao	Hot climates	The "cocoa-nibs" of the shops. Used as a beverage. Afford an oil or butter which can be used for burning.
Camelinc	Camelina sativa	Europe, etc	Oil from the seeds. Used for burning in lamps.
Candleberry	Myrica cerifera Myrica cordifolia	N. and C. Amer. Cape of G. Hope.	The berries contain a wax-like matter, which is converted into candles, producing an aromatic odor as they burn.
Candle-nut	Aleurites triloba	S. Sea Islands	Seeds contain oil. Used for food and for burning in lamps. Are strung on sticks by the natives, and so used as candles.
Carapa	Carapa guineënsis	W. Africa, etc	Seeds afford oil used by the natives for burning and anointing. In S. France made into soap.
Cocoa	Cocos nucifera	Hot climates	The oil of the cocoa-nut is the chief material from which composite, stearine, and other candles are made. Used also in soap-making and for "railway grease."
Colza	Brassica campestris	Europe	Seeds of a variety of the cabbage tribe afford this oil. Used in lamps; largely used in lighthouses.
Cotton	Glossypium herbaceum	Hot climates	Oil used for burning.
Crab	(See Carapa.)		
Dodder	(See Cameline-oil.)		

Common Name.	Botanical Name.	Native Place, or where chiefly grown.	Qualities, Uses, etc.
Fusel	Triticum, etc	Europe, etc	Seeds produce a peculiar oil. It gives the flavor to raw whiskey and is used for making flavoring extracts. Formerly used for burning.
Gingilie	(See Sesamum.)		
Ground-nut or earth-nut	Arachis hypogæa	Europe, etc	Affords oil used in cooking, burning, and for making soap.
Hazel	Corylus avellana	Europe, etc	Nuts afford oil. Sold as "nut-oil." Used by painters, perfumers, and medicinally.
Hemp-seed	Cannabis sativa	Europe, etc	Used for burning, paints, varnishes, and for soft soaps, etc.
Insect wax Japan wax Java wax	(See Wax.)		
Linseed	Linum usitatissimum	Europe, etc	Boiled with litharge produces the "boiled oil" of paints and varnishes Used in burning, etc. The refuse of the seeds affords the oil-cake for fattening cattle.
Maize	Zea mays	Warm climates	Oil extracted from the seeds.
Mee	Bassia longifolia	Tropics	Obtained from the seeds. Used for burning, etc.
Myrica wax Myrtle wax	(See Candleberry.)		
Mustard	Sinapis alba et nigra	Europe, etc	The husks and seed afford a fixed oil. Used for burning in lamps, etc.
Naneel	Bassia latifolia	Tropics	Oil obtained from the seeds. Used in burning, etc.
Nut-oil	(See Hazel and Walnut.)		
Olive	Olea europœa	Europe, etc	One of the purest of vegetable oils. Used in the arts and for salads In Italy is used in lamps.
Palm	Elais guineënsis	W. Africa	The fruit affords the palm-oil used in candle and soap making.
Pine	Pinus sylvestris	Europe, etc	Leaves afford an oil which can be made into soap.
Poppy	Papaver somniferum, *var.* nigrum	India, etc	Oil used extensively in the arts and for adulterating more expensive oils.
Rape	Brassica oleracea, etc	Europe, etc	Extensively used for burning in lamps. Colza is similar to it. When refined is equal to sperm-oil.
Sesamum	Sesamum indicum	India, etc	Seeds afford an oil used in India for cooking, burning, anointing, etc. Elsewhere used in lamps and for making soap.
Shea butter or oil	Bassia parkii	W. Africa	Seeds afford an oil used in Europe for candle and soap making, etc.
Souari-nut	Caryocar nuciferum, etc.	S. America	Contains a sweet oil. Much used in S. America.
Sunflower	Heliauthus annuus	Europe, etc	Seed yields an oil. Used in making fancy soaps, etc.
Tallow (vegetable).	Pentadesma butyra	Sierra Leone	Tallow, a term often applied to solid fatty substances obtained from plants. That produced from the seeds of the *Stillingia sebifera* is used for candles by the Chinese.
	Stillingia sebifera	China	
	Bassia butyraceæ	N. India	
Walnut	Juglans regia, etc	Europe and America	An oil often sold as "nut-oil." Used in the arts and to adulterate other oils.
Wax (bees)	.....	.....	Beeswax, although not strictly a vegetable production, is primarily derived from the pollen of flowers.
Wax (insect)	Fraxinus sinensis	China	A kind of wax deposited by an insect, the *coccus pe-la*, on the leaves of this species of ash.
Wax (Japan)	Rhus succedanea	Japan	A vegetable wax afforded by the fruit of the tree. Used in candle-making
Wax (palm)	Copernicia cerifera	Brazil	Wax obtained from the surface of the young leaves of the plant.
	Ceroxylon andicola	Andes	Wax obtained by scraping the trunk of the tree. Used [with tallow to make candles.
Wheat-oil	(See Fusel-oil.)		

Essential Oils.

Aniseed	Pimpinella anisum	Europe, etc	Seeds afford an oil used in medicine and flavoring spirits for liquors.
Bergamot	Citrus aurantium	S. Europe, etc	Rind of fruit affords an oil. Much used in perfumery, [essences, etc.
Cajeput	Metaleuca cajeputi	Moluccas	A volatile oil which dissolves india-rubber.
Camphor	Camphora officinarum	China, etc	A solid essential oil. Used in medicine, etc.
Cedar	Cedrus rubra	Generally	Wood yields an essential oil. Used in perfumery, etc.
Chamomile	Anthenus nobilis	Europe	The dried flowers afford an essential oil.
Citron	Citrus medica	Europe	Fragrant oil. Used by perfumers.
Citronelle	Andropogon citratum	India, etc	Obtained from lemon-grass. Used in perfumery.
Clove	Caryophyllus aromaticus	Tropics	Fragrant oil. Used in perfumery.
Fennel	Fœniculum vulgare	Britain, etc	Used in medicine.
Grass	Andropogon (various)	India	Obtained from various Indian grasses. Used in perfumery and medicine.
Jasmine	Jasminaceæ	Asia, Europe	A perfume. Obtained from the flowers by placing them in tallow and extracting by means of alcohol the volatile principle.
Lavender	Lavendula vera et spica	Europe	Oil used largely in perfumery and medicine.
Lemon-grass	Andropogon citratum	India	A delicious essential oil.
Lemon	Citrus limonum	Warm climates	The rind affords an oil used in perfumery, flavoring, etc.
Neroli	Citrus (various)	Europe	Perfumed oil obtained from various species of the orange family. Affords the "orange-flower water" of the shops, etc.
Nutmeg	Myristica moschata	Moluccas, etc	Essential oil. Used in perfumery.
Otto or attar of rose	Rosa moschata Centifolia, Damascena	Turkey and Syria.	A fragrant oil obtained from the Eastern species of rose.
Orange	(See Bergamot, Neroli.)		
Patchouli	Pogostemon patchouli	India	Plant affords an oil. Used as a perfume.

Common Name.	Botanical Name.	Native Place, or where chiefly grown.	Qualities, Uses, etc.
Peppermint-oil.....	Mentha piperita.....	Britain, etc.....	Used in medicine. [cine, etc.
Rosemary.....	Rosmarius officinalis...	Europe, etc.....	Tops of plant afford an oil. Used in perfumery, medi-
Sandal-wood or santal-wood	Santalum	India.....	Yields an essential oil heavier than water. Used in perfumery. [perfumery, and for flavoring.
Winter-green	Gaultheria procumbens.	N. America.....	The plant affords an essential oil. Used in medicine,

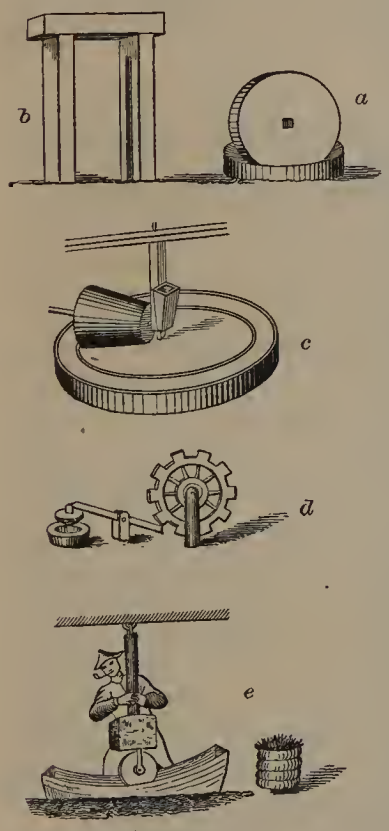
The most ancient oil-mills are those used for mashing the olive. They were used in Palestine at a very early date. Although Solomon, A. D. 1015, supplied Hiram with 20,000 baths of oil, in addition to the grain and wine, in return for the "timber of cedar and timber of fir," yet the Phœnicians themselves were great cultivators of the olive and traders in oil. The means they used were the mill, such as we now call the "Chilian," followed by a lever-press. The stones, bed-plates, and press-frames yet remain in the country to attest the fact.

Olives were known in ancient Egypt, and their cultivation was imported thence into Greece. Cecrops (1556 B. C.) is credited with the introduction of the tree, and Aristæus the Athenian (1450 B. C.) was deified as the inventor of expressing-machinery.

They were introduced into Italy about 562 B. C., during the reign of Servius Tullius, which was coeval with that of Nebuchadnezzar, and with the prophecies of Daniel. This was nearly 100 years before Marathon.

The Phœnician mill is shown at *a* in the accompanying cut, which is taken from Thompson's Researches in Palestine. It is drawn from one at Em el' Awamêd. The stone wheel had an eye for the shaft, to which the draft animals were attached, and the fruit was mashed by the revolution of the stone in the basin.

Fig. 3381.



Oil Mills and Presses.

The press-frame (*b*) consisted of two upright posts and a very heavy cross-piece, being evidently a *beam* or *lever* press. A beam above the platen which rested on the olive-cheese traversed in grooves on the inner faces of the posts, and was depressed by a weighted beam. This was before Archimedes and the screw.

The basin represented is 8 feet in diameter, and a stone trough in the vicinity was doubtless used to receive the oil as it flowed from the press.

The basins and posts with huge stones on top are numerous in some sections of Palestine, where the long-lived olive has rotted away and left no trace. 2,400 years have passed since these lands were fully tended; the Assyrian, Persian, Greek, Roman, Saracen, and Turk have overrun the land, and the modern Syria is now occupied by a million and a half of people divided, by race or religion, into 16 tribes, who are Ishmaelites in *deed* and many of them in *blood*.

The Spanish olive-mill (*c*) is used for crushing that fruit to obtain the oil, which stands instead of butter and lard in a land that once afforded Columella a subject for praise in the conduct and productions of the dairies of Andalusia. The Spain of to-day is not what it was in the time of Cato, nor indeed what it was under the occupancy of the Saracens. It has probably retrograded in health, wealth, morals, productiveness, and in scholastic and executive ability.

Loudon remarks, that although the olive is grown in Spain in greater perfection than in Italy, owing to some manorial rights or a system of farming the taxes, all the olives of a district are brought to one place to be ground and pressed; and as each heap has to wait its turn, the olives in many of the heaps become black and rancid.

A friend of the missionary W. M. Thompson, who farmed the district of el Mughar, near the lake of Tiberias, states that a black color does not hurt the olives as they lie in the heap. The modern Syrian plan embraces two modes of grinding the fruit and expressing the oil:—

1. The *m' aserah*, which is worked by hand and used for grinding the early fruit before the streams are raised by the winter rains which start the water-mills. In the *m' aserah* the fruit is ground by a revolving stone in a stone basin, much as in the ancient Phœnician method just described. It is pressed in a beam or screw press, the mass being packed into straw baskets, which are piled one above another in the press. The cheeses, after one pressure, are broken up, put in copper pans over a fire, sprinkled with water, heated, and re-pressed.

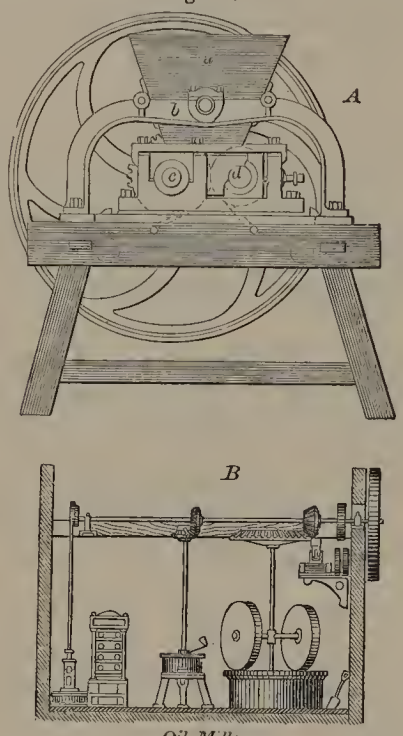
2. The *mutruf*, driven by water-power, and pounding the olives with a stamp in a heated, vertical stone cylinder. The face of the stamp is of iron cross-bars, and it is rotated as it works. The mass is taken out below, put in baskets, and pressed. The process is repeated. The details of the operation are probably almost identical with those in vogue 3,000 years ago.

In China, the pestle and mortar (*d*) are used in reducing to powder the seeds of the oil-bearing tea-plant. The meal is boiled in bags and pressed to yield the oil. The lever is tripped by the cogs of the sprocket-wheel, and falls by gravity.

e shows the press used in China in crushing the seeds of the tallow-tree. The weighted wheel is suspended by a rod from a beam, and is oscillated to and fro by the workman, traveling upon the seeds which are placed in the trough below. The oil procured from the bruised seeds by heat and pressure is added to vegetable oil and wax to the required consistence for candles.

A (Fig. 3382) illustrates a mill for crushing seeds preparatory to extracting the oil therefrom by pressure. The seeds are fed from the hopper *a* by a roller

Fig. 3382.



Oil-Mills.

b, the amount being regulated by an adjustable plate, and pass between the crushing-rollers *c d*, the smaller one of which has adjustable bearings, so that the distance between them may be varied. The larger roller is driven by belt and pulley, and has a spur-gear which moves the smaller one.

B shows a mill, heater, and press combined.

Fig. 3383 is the olive-mill of Barbary.

Fig 3383.

Olive-Mill of Barbary.

Oil-of-brick. An empyreumatic oil used by lapidaries as a vehicle for emery, by which precious stones are sawn or cut.

The brick is soaked in oil and subjected to distillation at a high temperature.

Oil-painting. The process of painting with colors held in solution by volatile or evaporable oils which, on drying, leave the pigment combined with the solid constituents of the oil, upon the surface to which it has been applied.

Linseed-oil was undoubtedly used as a medium for painting in very early times, but the term "oil-painting" has by custom become restricted to the fine arts.

The pictorial representations of the ancient Egyptians were executed upon a ground of plaster or calcareous wash; the colors, according to modern analysis, were mixed with a resinous size or animal glue, and the whole covered with a coat of varnish.

Analogous substances for holding and fixing the colors appear to have been in use down to the latter part of the thirteenth or early part of the fourteenth century.

The oldest painting in oil-colors at present known was painted in the year 1297, by Thomas de Mutina or de Mutterfdorf, in Bohemia. It is in the Imperial Gallery of Bohemia. Two other paintings are in the same collection, by Nicholas Wurmser of Strasburg, and Thierry of Prague, respectively.

These paintings antedate by many years those of Hubert and John Van Eyck of Bruges, who lived during the earlier part of the fifteenth century, and to whom the invention of oil-painting is generally ascribed.

Oil-press. A press for extracting oil from the seeds of various plants. Formerly, linseed constituted by much the largest source of supply, but within the past few years cotton-seed is largely used, it as well as linseed yielding a large proportion of oil, beside meal or cake well adapted for feeding cattle or hogs. Cotton-seed (excepting Sea Island) is preferably decortieated previous to being ground and pressed, otherwise the treatment of these and linseed is the same.

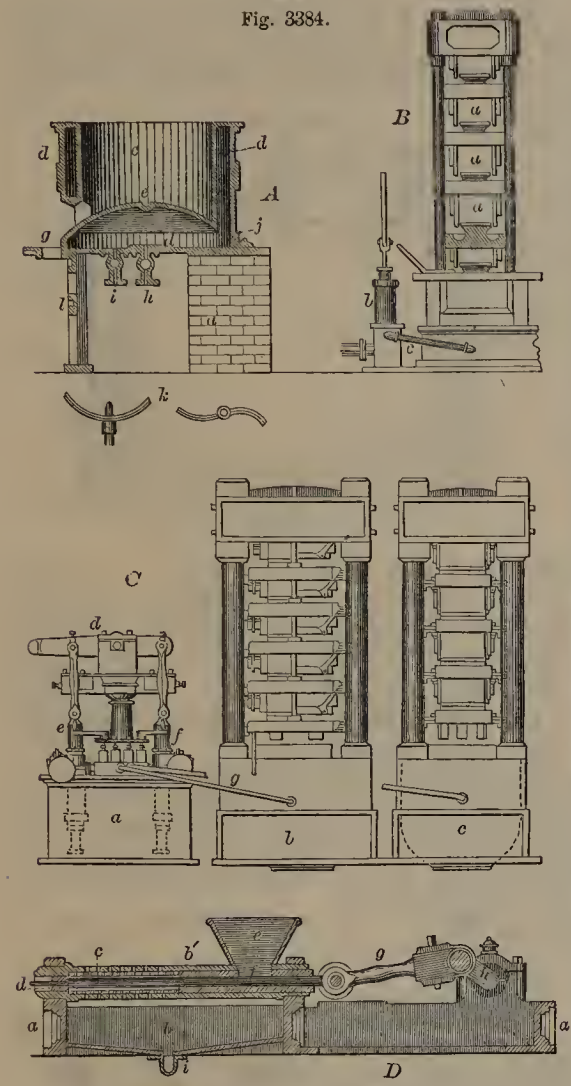
The seed is first passed between two rollers, one of which revolves more rapidly than the other, subjecting it to a drawing as well as a crushing action; from these it is transferred to the chasers, two heavy circular stones turning upon a third stone, and moistened with water to prevent the meal from adhering; when thoroughly ground it is put in a heater; of this there are several forms: that shown at *A*, Fig. 3384, consists of a cast-iron cylinder *c* supported by the brick foundation *a*, surrounded by a steam-jacket *d d*, to which steam is admitted through the pipe *h*, the water of condensation being drawn off through *i*. A charge of meal is introduced into the cylinder and agitated by a rotary stirrer stepped in the depression *e*; the steam is let on, and when a temperature of 180° to 190° Fah. is attained the gate is opened and the meal withdrawn, falling through the aperture *g* into a bag beneath; the bag being partially filled, its unfilled portion is turned over so as to close its mouth, and it is placed within a squeezer made of horsehair cord covered with leather, and having a handle attached by copper rivets. These are then introduced within the boxes *a a a* of the hydraulic press *B*, and subjected to pressure; *b* is the pump, and *c* the pipe by which its pressure is transmitted to the ram of the press.

C represents Blundell's press, *a b* a side and *c* an end elevation; *d*, the operating-lever; *e f*, plungers and pump-cylinders; *g*, pipe transmitting pressure to the ram.

D is a plunger-press, to be presently described.

The product of oil is about 2 gallons from a bushel of linseed, or 56 pounds of hulled cotton-seed; that

Fig. 3384.



Oil-Heater, Presser, and Hydrostatic-Press Pump.

from Sea Island seed, which does not require hulling, is about 90 gallons from each 100 bushels.

"The oil-press was invented by Aristæus, the Athenian"; so says Pliny. To find the date at which he flourished, we must consult the marriage register. He was a son of Apollo, but married a daughter of Cadmus about 1450 B. C., let us say. He found time between his spells of running after Eurydice to instruct men in the culture of the olive and of bees. This was about the time of Joshua. Archæologists have shown it to be probable that the Phœnicians practiced both the arts before Aristæus destroyed the harmony in the household of Orpheus.

The oil-press used by the Phœnicians in the time of Solomon, and substantially in use at the present day in Syria and Palestine, consists of two posts and a very heavy lintel. The press is illustrated in OIL-MILLS (which see) in connection with the basin and revolving stone by which the fruit is ground. The crushed fruit in straw baskets was (and is) placed on a bed-piece, the platen adjusted, an upper beam laid upon the platen, its ends traversing in grooves on the inner faces of the posts as it was pressed down by a lever above. This accounts for the lintel being so heavy, as it was required to resist the upward thrust of the lever. The screw-press was then unknown.

The olive is a native of Asia, from which it has been transported to Africa and Southern Europe.

The wedge-press, which is sometimes used for expressing linseed-oil from the hot magma, is a somewhat crude but powerful press. The bags of ground seed are placed in bags between followers, which are driven toward each other by wedges driven in above and below.

The hydraulic press does not differ substantially from that employed for other purposes, and is described under HYDROSTATIC PRESS (which see).

In the English practice, the flaxseed is crushed between rollers, then ground beneath an edge-stone, heated, filled into bags, and then pressed in a wedge-press or a hydraulic press.

The castor-oil plant (*Ricinus communis*) was well known to the Egyptians, and is called *silli-cyprium* by Herodotus, and *kiki* by the inhabitants of Egypt. The oil was then extracted by pressure or by boiling, and used for anointing. It was probably Jonah's plant, *kikion*, being mistranslated *gourd*. Herodotus and Pliny claimed that it smelt badly, but had its uses medicinally.

Bessemer and Heywood's machine (*D*, Fig. 3384) for expressing oil from seeds (English) consists of a bed-plate or framing *a a*, cast in one piece and having a receptacle *b* for receiving the expressed oil. The frame supports a gun-metal cylinder *b'*, within which is fitted a tube *c*, having a spiral exterior perforated groove, and lined with an open-ended bag of coarse fabric containing a cylinder of wire gauze or perforated metal. The cylinder *b* is contracted at *d*, so as to support the interior tube against longitudinal pressure, and prevent the rapid escape of the pressed seed. The seeds are placed in the hopper *c*, and as the plunger *f* is drawn back by the connecting-rod *g* on the crank-arm *h*, a portion falls into the tube, and on its return movement is forced into the bag before described, where the seeds are crushed, a portion of the cake thus formed being at the same time expelled through the contracted end of the tube. The expressed oil passes through the openings in the inner and outer cylinders, whence it is withdrawn by the pipe *i*.

Oil-pump. A pump to raise oil from a can or reservoir and discharge it on to a journal.

Oil-re-fin'ing Ap'pa-ra'tus. The apparatus employed for separating the various ingredients contained in crude petroleum in the process of obtaining kerosene consist of an iron still having a wrought-iron worm-pipe, which is submerged in a tank containing cold water. The still having been filled with crude oil, a fire lighted beneath it causes the oil to boil, and drives off the more volatile vapors which at ordinary temperatures pass over without being condensed. By surrounding the coil with ice or by compressing these gases by means of an air-pump, they may be condensed into the form of very volatile liquids, termed *rhigolene* and *chymogene*.

After these have been eliminated, the vapors begin to condense in the coil, the resulting oil being received in a tank at its farther end. That first formed has a gravity of about 95° Beaumé, but the product becomes heavier as the process proceeds. It is usually customary to direct the stream into one tank until the gravity reaches from 65° to 59° B., forming crude naphtha, when it is diverted into the kerosene tank, into which it is allowed to flow until a gravity of about 38° B. is reached, or the oil becomes of a yellow color. This second fraction is the burning-oil, which requires a farther purification to fit it for use. The stream is next directed into the paraffine oil-tanks, and allowed to run until nothing remains in the still except coke. When, however, very large stills of 1,000 barrels capacity or upward are employed, the distillation is stopped when the

residuum has attained a tarry consistence, the remaining oil being extracted in smaller stills.

By slow distillation in high stills, the production of the heavier oils may be avoided, they being "cracked" into lighter oils, so that only crude naphtha, kerosene, and coke result.

The burning-oil is purified by the addition of about two per cent of sulphuric acid to improve the color and deodorize it. The acid is poured into the oil, and the liquid thoroughly agitated and then allowed to stand, when a dark tarry residuum separates. This is removed, and the clear oil is then agitated with water and afterward with caustic soda or ammonia. This neutralizes any remaining traces of acid, and is removed by water. In some instances it is then heated to expel a small proportion of naphtha or benzine which it may contain, or is redistilled.

The crude naphtha is redistilled for gasoline, benzine, or refined naphtha, or is poured into the oil-wells, nominally for the purpose of cleaning them. In some instances it is used for adulterating the crude oil sold to the refiner.

In the details of the process of refining, manufacturers somewhat differ. Some blow steam through the crude oil, thus taking off the naphtha previous to distillation. In other instances, the heavier portions of the distillate are separated, forming safer oils than those in ordinary use. Thus, "astral oil," averaging 49° B., flashes at 125° of Fahrenheit's scale, and "mineral sperm," having a gravity of 36° B., only yields inflammable vapor at temperatures above 262°.

Oil which flashes at or above 100° F. is considered safe for ordinary use, but the temptation to allow the heavier portion of the crude naphtha, an article which commands a much lower price than oil, to flow into the tank designed for the latter is so great that many kinds of oil in the market are very dangerous, their vapors exploding at a much lower point.

Instead of continuing the flow of naphtha into its proper tank until a gravity of 58° or 59° B. is attained, it is diverted into the burning-oil reservoir while yet as light as 63° to 65°.

Dr. White of New Orleans found that one per cent of naphtha added to an oil which flashed at 133° Fah. caused it to flash at . . . . 103°

2 per cent	92°
5 per cent	83°
10 per cent	59°
20 per cent	40°

Ordinary kerosene, having a gravity of 47° B., flashes at 86° Fah. An oil which will not flash below 100° may be made by running off the naphtha to 58° B., and exposing the oil in shallow tanks to the sun or a strong light for a day or two.

The average yield of crude Pennsylvania oil is stated to be: —

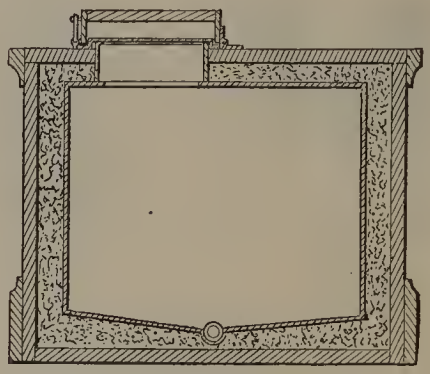
Gasolene	1½
Refined naphtha	10
Benzine	4
Refined petroleum or kerosene .	55
Lubricating oil	17½
Paraffine	2
Loss, gas, and coke	10
	100

By *cracking* it can be made to yield, —

Crude naphtha	20
Burning oil	66
Coke and loss	14
	100

Oil-safe. A storage-vessel for oil, protected from access of fire, and measurably from the heat of the surrounding atmosphere. It consists of a vessel of

Fig. 3385.



Oil-Safe.

sheet-metal with soldered joints in a box of wood with an intervening material which is a poor conductor of heat. Oil is poured in at the top and discharged by pipe and faucet at the bottom.

Oil-skin. Cloth treated with oil to make it water and perspiration proof.

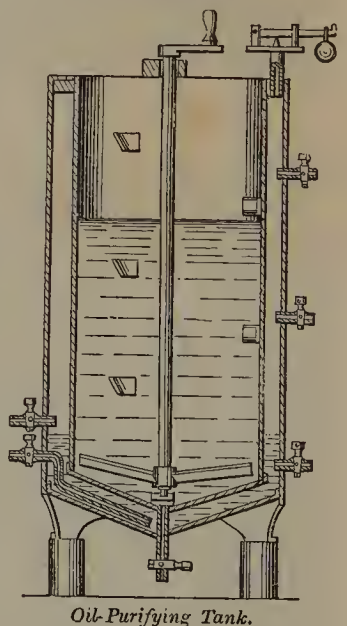
Oil-still. A still for hydrocarbons, notably petroleum. See PETROLEUM-STILL.

Oil-stone. A slab of fine-grained stone, set in a wooden block and provided with a wooden cover, used for imparting a keen edge to tools: it is so called because oil is used for lubricating its rubbing surface. See WHETSTONE. See list under GRINDING AND POLISHING.

Oil-tank. A large vessel for holding oil for —

1. Treatment.
2. Storage.
3. Transportation.

Fig. 3386.



Oil-Purifying Tank.

1. Tanks for treatment are usually large reservoirs or vats. Two illustrations may be given.

In Fig. 3386, the oil or fat is placed in the inner tank, which has a vertical shaft having radial stirrers and a discharge-pipe at its lower conical end. It is surrounded by a water or steam chamber, by which the oil or fat is heated to 90° or 100° Fah., respectively, and yeast, 3 parts, added to 40 parts of the grease. The whole is stirred while warm, and then left to ferment, when sediment is drawn off at the bottom. The tank may be used in the manufacture of stearine. See also LARD-TANK.

Fig. 3387 shows an arrangement of tanks for carrying out successively the operations of oxidizing, neutralizing, steaming and heating for evaporation, oils to be purified; and of special devices to be employed in connection with one or more of the tanks for the addition of oxidizing and neutralizing chemicals to the oils, for stirring and agitating the same, and for

indicating the condition of the contents of the several tanks.

The oxidizing-tank *A* is provided with a detachable stirring-shaft *H*, and diffusing-sieve *P*. On the next step is a neutralizing-tank *B* with sieve *P'* at top, and steam or hot-air pipes *Q* within the same. Third in the series is a steaming-tank *C*, containing suitable steam-jet pipes *R*, and fourth is an evaporating-tank *D*, the whole being adapted and made to operate

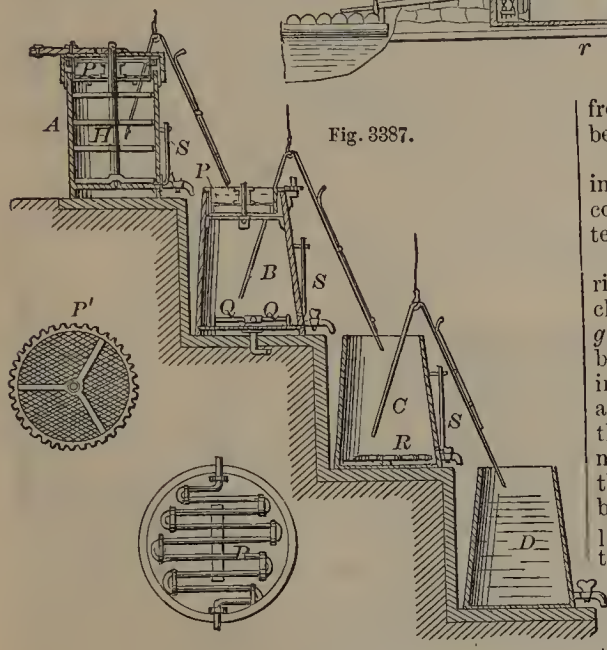


Fig. 3387.

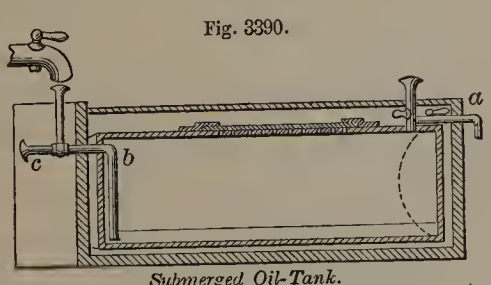
Tanks for the Purification of Oil.

consecutively upon the same body of oil as it flows from one to another in the series.

Each vat has its gage-glass *S*, and the discharge is also by pipes. *K* is the man-hole cover. Water enters below the oil in the tank, the level being evidenced by a gage.

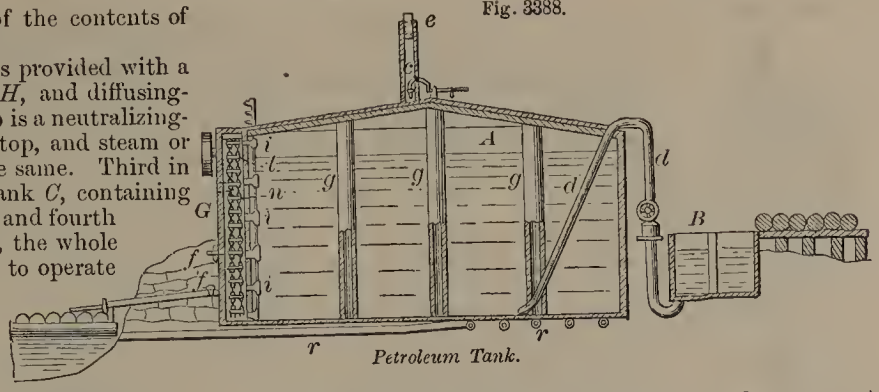
In Fig. 3390, the water in the submerged tank is displaced by oil introduced from above; the stratum of water escapes by rising through a pipe *b* and overflowing. Oil is discharged at *a* by admitting water.

Fig. 3390.



Submerged Oil-Tank.

Fig. 3388.



Petroleum Tank.

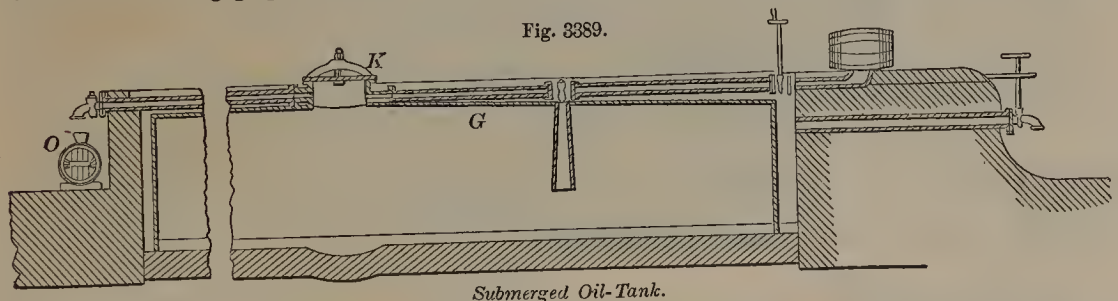
from each tank of the upper three to the one next beneath it is by siphon.

2. *Tanks for storage* are usually on a large scale, in obedience to the law of economy of material in construction, being much less per cubic foot of contents for large vessels than for small.

Fig. 3388 is a petroleum tank, shown as upon a river-bank. The tank *A* is of metal, is hermetically closed, and its roof is supported by hollow columns *g g*. Above is an escape where volatile gases are burnt as at a gas-burner. *B* is the receiving-tank into which the barrels of oil from the well are emptied, and from which the oil flows into the tank *A* through the siphon *d*. *G* is the delivering-chamber with a number of valves *i i* at different hights leading from the tank *A*, so that oil of different gravities may be drawn from different altitudes. The entrance-pipe *d* delivers the fresh oil into the bottom of the tank in contact with the heavier stratum of oil, depositing the paraffine at the bottom. *r* is a heating coil, for use if necessary. *f f* are delivering faucets to the pipe which leads to the barrels in the boat alongside the river-bank.

Fig. 3389 shows a form of submerged tank, the iron oil-chamber being placed in a pit with water around and above it. The oil is introduced and discharged by pipes. The induction and overflow of the water

Fig. 3389.



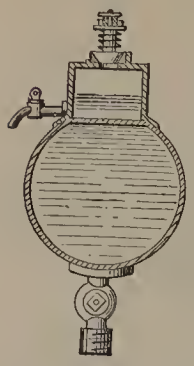
Submerged Oil-Tank.

3. *Tanks for transportation* are made of a size to form a load for a platform, on which they remain, being filled and discharged by pipes and hose (see OIL-CAR); or are of such a size that they may be swung or rolled on to the car. The latter includes boiler-iron barrels, and those of wood, pitched or otherwise treated to render them impervious to oil.

Church's petroleum tank (Fig. 3391) has upon its top a chamber with a safety-valve to enable it to be kept full without endangering it when the contents expand or contract by changes of temperature.

In Fig. 3392 the tank has an air-chamber in any convenient part provided with a safety-valve. A bent tube extends from the petroleum-tank into the air-chamber, the ends terminating a short distance

Fig. 3391.



Church's Oil-Tank.

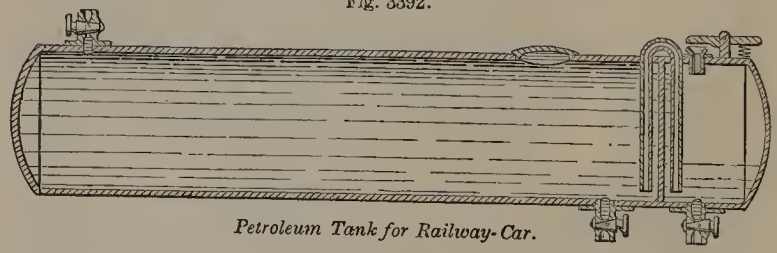
above the bottom of the tank and air-chamber. The tank is filled with petroleum, and enough is placed in the air-chamber to cover the end of the bent pipe under all circumstances of expansion and contraction, so as to prevent the accession of air to the main chamber.

As the petroleum expands it flows into the air-chamber, condensing the air; as contraction of its bulk occurs it flows back to the main reservoir.

In Fig. 3393, the safety-chamber is introduced to afford a space into which the oil may expand, and from which it returns when contracting. The chamber is detachable and capable of introduction into the tank or barrel at the ordinary opening for filling.

Other forms of tanks for transportation are built

Fig. 3392.

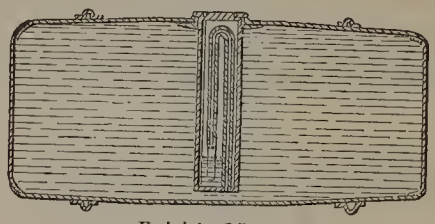


Petroleum Tank for Railway-Car.

of metal, inside box-cars, with devices for staying, filling, emptying, etc.

Much ingenuity has been expended in making

Fig. 3393.

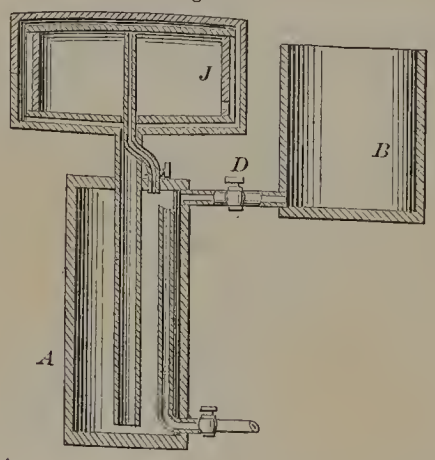


Knight's Oil-Tank.

barrels of wood or of metal for shipping petroleum and coal-oil.

Day and Chapman's metallic barrel is inclosed in one of wood.

Fig. 3394.



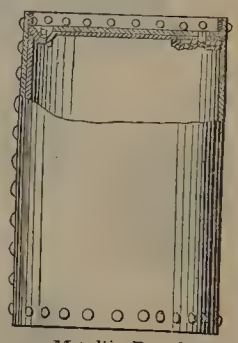
Apparatus for applying Solutions to Oil-Barrels.

Fig. 3394 shows an apparatus for applying solutions to oil-barrels to render them impervious to oil. The barrel *J* is placed in the upper chamber and the lid closed tightly. The solution from vat *B* is allowed to flow into *A*, and the faucet *D* is then closed. Steam is then admitted from the pipe entering the bottom of the closed vessel *A*, and, collecting in the top of the vessel, forces the liquid into the chamber in which the cask *J* is placed. When the cask is saturated, the steam is shut off and allowed to flow by faucet *D* into chamber *B*; the liquid sinks from the upper chamber, the lid is lifted, and the cask removed.

Barnum and McNoah's metallic barrel (Fig. 3395) is coated on both sides with lead, and the joints made by riveting and soldering.

There are many patents for compositions, modes, and machinery for thus impregnating, and for coating barrels for this purpose.

Fig 3395.



Metallic Barrel.

Oil-test. For ascertaining the degree of heat at which the hydrocarbon vapors of petroleum are liable to explode.

That legally employed in Great Britain consists in heating the oil in a porcelain vessel surrounded by a hot-water bath. A wire is placed ¼ inch above the rim of the vessel, and when a thermometer whose bulb is submerged 1½ inches below the surface of the oil indicates the desired heat, say, 90°, a small flame is passed quickly along the wire over the surface of the oil; if no flash is produced, the heat is continued and the test applied at every 3° above this until the flashing-point is reached. The operation is then repeated with a fresh sample of oil, fresh water being used in the outer vessel, the source of heat being removed when a temperature approaching that obtained in the first experiment has been reached. A *fire-test.* See PETROLEUM-TESTER.

Oil-well. The first borings for oil were made at Titusville, Pa., 1859, by Mr. E. L. Drake. Previous to this the petroleum was collected by blankets on the surface of springs and bottled for medicinal use. Nothing was then known of its use for lighting or lubricating. Mr. Drake had great difficulty in obtaining competent drillers, so absurd was deemed the project of searching for a basin of oil beneath the surface. He then gave out that he was boring for a salt-well. He originated the practice of driving a tube to the rock, instead of excavating and cribbing. He drove a tube 32 feet, and then bored 37½ feet. He tubed the well, and obtained by hand-pump 25 barrels per day for two years. It was difficult then to find use for so much. The first refiners were McKeown and Kier of Pittsburgh.

Oil-wells are of various depths, but the mode of sinking them is substantially similar. They vary in depth from 100 to 1,100 feet. After a spot is decided upon, a derrick is built, having four diverging posts planted upon a base of about 12 feet square, and having a hight of 40 feet. So great interest has been felt in the subject, and so frequently has the

matter been described in the magazines and journals of the day, that we do not deem it advisable to afford much space to the description of the *modus operandi*. We give a condensation of the description given by a writer in "Harper's Magazine."

The engine-house being erected and the necessary machinery all ready therein, sections of iron pipe, 6 inches in diameter, are driven into the ground by means of a pile-driver until the first layer of rock is reached, which, in most cases, is found at a depth of 35 or 40 feet below the surface of the ground. Great care is taken that this iron pipe is driven plumb. After the rock is reached and the earth within the pipe is removed, a block and tackle is rigged at the top of the derrick, and the drilling-tools, weighing in some cases 900 pounds, are hoisted up and dropped into the driving-pipe down to the rock. A temper-screw is then attached to the top of the drill, by means of a rope, and made fast to the end of a walking-beam, which is a heavy horizontal piece of timber, vibrating on its axis and supported by a Samson-post. The other end of the walking-beam connects with the driving-pulley by means of a crank. The engine drives the pulley, the end of the walking-beam rises and falls, giving the vertical motion to the drill-rod and drill. At intervals, during the process of drilling, a tool called a *reamer* is inserted into the well, its duty being to bring the bore to the proper size and shape. A sand-pump is a metallic tube, from 5 to 10 feet in length, and having a valve in the bottom, opening upwardly. (See SAND-PUMP.) This sand-pump is lowered into the well at intervals, and when it reaches the bottom the valve opens and admits the borings; when the pump is raised, the valve closes and the contents are brought to the surface. After the bore is thus cleaned, the drill is again inserted and the drilling is continued.

In boring a well, a correct journal is kept, showing the different kinds of rock and earth passed through, and the exact points where water-courses, gas, or shows of oil are found.

If a large vein of oil be struck, the well is immediately tubed with 2 or $2\frac{1}{2}$ inch pipe, put together in sections with couplings. The water from veins and from the surface is prevented from running down the well, outside the pipe, by means of a leathern bag filled with flaxseed; the swelling of the seed completely closes all communication between the top and bottom of the well outside the tubing.

If the vein of oil struck prove to be large, and the pressure of gas is sufficient, the oil will flow out without the aid of a pump; but in most cases a pump is required, in which case a copper working-barrel is placed at the bottom of the well and attached to the lower section of the tubing, with a valve at the bottom. The upper valve is connected with a sucker-rod, the end of which is attached to the end of the walking-beam.

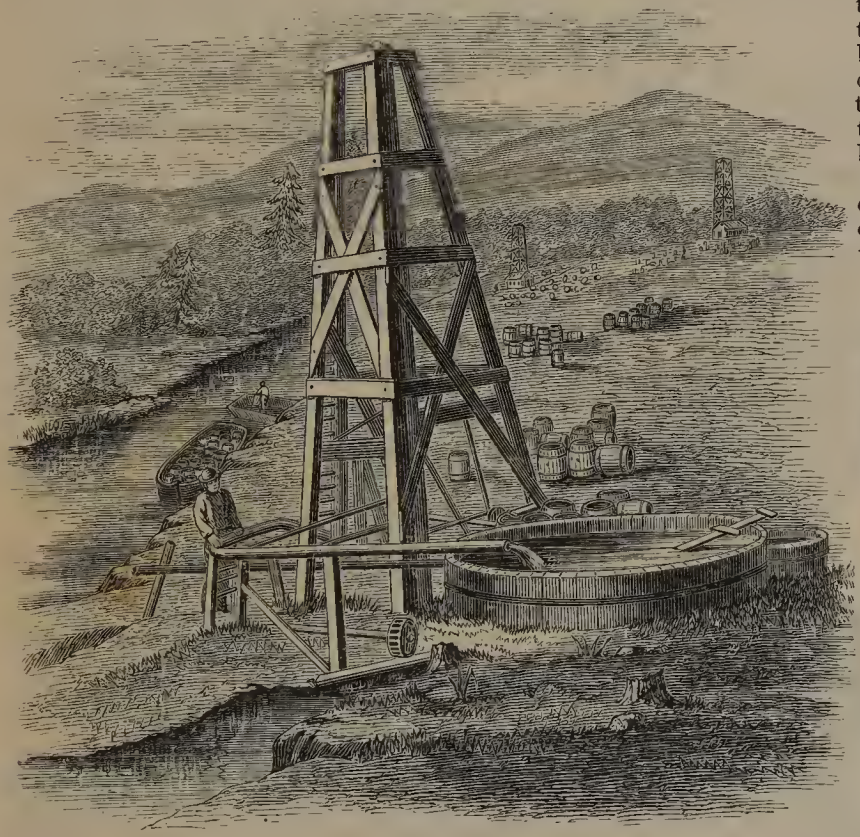
The tanks or tubs to receive the oil are mostly made of wooden staves, but sometimes of boiler-iron, and are placed at some distance from the well; they are connected with it by means of iron pipes attached to the spout of the pump.

It is almost impossible to give the exact cost of sinking and completing a well. Prices vary in different localities, and the cost of drilling ranges from $2 to $3.50 per foot. It may be estimated at an average of $5,500. The tools have been incidentally referred to, and are shown in the accompanying cut. The drill-stem consists of sections of iron rod connected by screw-couplings.

The ordinary drill has a chisel face, but a great deal of ingenuity has been expended on this part of the apparatus. Several varieties are cited under the captions ARTESIAN-WELL; ROCK-DRILL; WELL-BORING, etc.

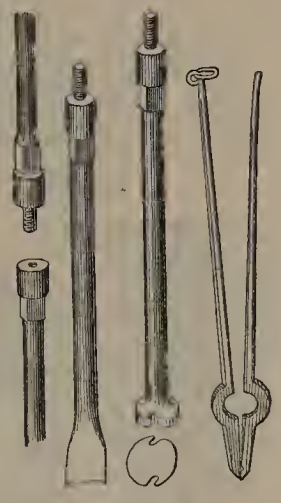
The reamer is introduced into the bore to *true* it; the drill fails to make a smooth hole, and the reamer

Fig. 3396.



Oil-Flowing Well.

Fig. 3397.



Drilling-Tools.

is about circular in its form, giving a perfect shape, and fitting the bore to receive the tube.

The pipe-tongs is adapted to grasp the drill-rod or tube while a new hitch is being taken in withdrawing or introducing either.

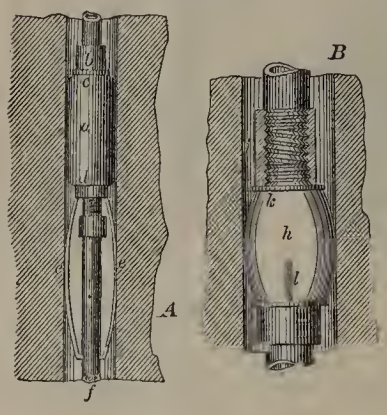
The presence of oil in springs has been noticed from time immemorial, and the rock-oil, Seneca oil, or whatever custom or charlatans have called it, has been famous either as having a sacred character or association, as in the famous wells of the Caspian, or as a liniment. Bitumen, asphatc, bituminous shales and rocks, are found in many parts of the world, and the references to the subject are found scattered in the writings of Herodotus, Pliny, and very many others of the writers of antiquity.

"It is said that on digging near the river Ochus [in Bactria] a spring of oil was discovered. It is probable that as certain nitrous, astringent, bituminous, and sulphurous fluids permeate the earth, greasy fluids may be found, but the rarity of their occurrence makes their existence almost doubtful." — STRABO, A. D. 16.

See PETROLEUM.

Oil-well Pack'ing. The usual method of packing oil-wells has been by a *seed-bag*, so called, consisting of a leathern bag filled with flaxseed and placed around the tube, to fill the space between the latter and the sides of the well. The office of the seed-bag is to prevent the water which percolates through upper strata from reaching the bottom of the well, where it would float the oil, and require to be pumped out before the oil would sink to a point where the end of the tube could reach it. It has a farther office in some wells, where a heavy pressure of gas is present, as the said pressure would elevate the oil, perhaps to the surface, were not a way of escape found around the tube, between it and the wall of the well. The seed, becoming saturated with water, swells and forcibly presses the leathern bag against the well-tube and the wall, and the device has proved very effective. It is, however, almost impossible to withdraw it, for the purposes of removing the tubing. The practice has been to "spear" the bag, to allow its contents to escape and permit the leather bag to collapse; but this operation has proved tedious and uncertain, owing to the small limits of the working space and the distance from the surface of the ground.

Fig. 3398.



Oil-Well Packing.

In *A* (Fig. 3398) *a* is an elastic substance surrounding the main tubing, *b* is the ordinary coupling, resting upon the washer *c*, their surfaces ground together and made water-tight; *d* is a loose nut, running upon a screw-thread cut on the main tubing. *c e* are elliptic springs, dovetailed or otherwise fastened to the sides of the loose nut *d*, and partially clasping the tubing at *f*, also pressing the walls of the well at *g*, thereby holding the loose nut firmly and preventing its rotation.

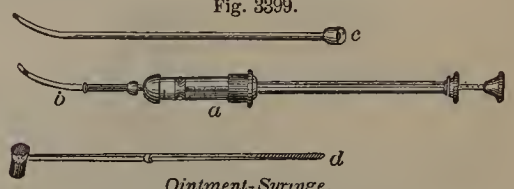
By rotating the tubing from the top of the well while suspended in the tackle, the loose nut *d* is drawn up, expanding the packing and effectually filling the bore of the well.

By rotating the tubing in the other direction, the nut descends and loosens the packing, thereby freeing the tube and allowing it to be withdrawn, if necessary.

Another form is shown at *B*. A cylinder *h* of any elastic substance not affected by oil is placed between two washers about the well-tube. The cylinder is slightly smaller than the bore of the well, and is easily let down therein; but on reaching its position it is compressed by screwing the tube itself down into a long coupling: this action forces the washer *k* against the packing, and squeezes it out so as to fill the passage completely. The packing rests at the bottom on a fixed washer, and has also four ribs *l* to hold it from turning while the tube is screwed up. It will be seen that the thread is not exposed at any point.

Oint'ment-syr'inge. (*Surgical.*) One employed to apply caustic, etc., in the form of ointment, to deep-seated places. The syringe *a* is shown

Fig. 3399.



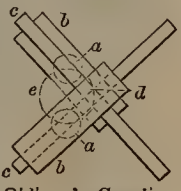
Ointment-Syringe.

with two silver flexible tubes, one *b* for the uterus and the other *c* for the male urethra. The instrument forms a *porte-caustic*.

d is a platinum spoon for melting caustic.

Old'ham's Coup'ling. A sliding coupling for parallel shafts, invented by Oldham. *a a* are the axes of two shafts; *b b*, two cross-heads on their ends; *c c*, bars sliding in grooves in the cross-heads: the bars are fixed together at their midlengths so as to form a cross, the middle point *d* of which revolves upon the dotted circle *e* described on the line of centers, so that its axis of rotation at any instant is at a point in that circle diametrically opposite to *d*. See TRAMMEL.

Fig. 3400.



Oldham's Coupling.

Old-sand. (*Founding.*) The sand forming the floor of the molding-shop to the depth of two or three feet, and filling the deep pits under the cranes. It is generally quite black, is weak and friable, and unfit for the face of any mold. On the other hand, its porous character makes it well suited for filling the flasks over the *facing-sand*.

O'le-ine. The fluid portion of fats and oils after the stearine or more solid portion has been removed.

O'le-o-mar'ga-rin. A substitute for butter. It is prepared by chopping clean animal fat fine, and boiling it; when cool it is churned with pure fresh milk, washed, worked over, salted, and packed for market. It is claimed that this article is scarcely distinguishable from pure butter, and that in consequence of its superior keeping properties it is peculiarly adapted for exportation to warm climates.

O'le-om'e-ter. A species of hydrometer adapted for determining the relative densities of oils.

One form of oleometer, invented by Professor Palmieri of Naples, consists of an electrical apparatus of great delicacy, the object of which is to detect the admixture of other oils with that of the pure olive. The instrument is founded on the fact of the variability in the powers of conduction possessed by the various oils, olive being lowest in the scale. The wires of

a battery are brought to a small elongated vessel containing the oil to be examined, and, an electrometer being attached, the degree of conductivity can be read off on a scale. The instrument, it is said, can detect any of the usual adulterants with the utmost nicety. It has also been applied to the detection of woolen or cotton fibers in silk fabrics.

Ol'ive. An escutcheon attached to the strap of a traveling bag or satchel and perforated for the passage of the swiveled stud or button.

Ol'i-ver. A forge-hammer whose handle is attached to an axle and which is worked by a treadle and spring.

It is usually a small lift-hammer, worked by the foot. The hammer-head is about 2½ inches square and 10 inches long, with a swage-tool having a conical crease attached to it, and a corresponding swage is fixed in a square cast-iron anvil-block, about 12 inches square and 6 deep, with one or two round holes for punching, etc. The hammer-handle is about 2 to 2½ feet long, and mounted in a cross-spindle nearly as long, supported in a wooden frame between end-screws, to adjust the groove in the hammer-face to that in the anvil-block. A short arm, 5 or 6 inches long, is attached to the right end of the hammer-axis; and from this arm proceeds a rod to a spring-pole overhead, and also a chain to a treadle a little above the floor of the smithy.

Om-brom e-ter. A RAIN-GAGE (which see).

Om'ni-bus. 1. (*Glass-making.*) A sheet-iron cover for articles in a *leer* or annealing-arch, in order to protect them from drafts of air.

2. (*Vehicle.*) A large four-wheeled vehicle to carry passengers; the seats being usually arranged on each side, the passengers facing, and the door at the rear.

Established in Paris by a decree of Louis XIV., 1662, and made to hold eight persons. Re-established, 1819. In England in 1829. Amsterdam, 1839

Om'ni-graph. A PANTOGRAPH (which see).

On'a-ger. An ancient military engine for hurling stones out of a cup-shaped receptacle.

Ooze. A solution of tannin obtained by infusing or boiling oak-bark, sumac, catechu, or other tannin-yielding vegetable.

There are many ways of extracting the ooze: —

1. By cold water.
2. By hot water, steam being conducted to the vats.
3. By boiling, the spent or weak liquor from the pits being employed.
4. By hydrostatic pressure; the ground bark is placed in a strongly bound vessel with a perforated false bottom; a column of water 20 or 30 feet high rests upon the bark and forces the water to filter through the mass.

O'pal-ine. A semi-translucent glass, also known as *fusible porcelain* or *milk-glass.* It is a glass whitened by the addition of phosphate of lime, peroxide of tin, or other ingredients.

O-pal'o-type. (*Photography.*) A picture on milky glass.

O-paque'-disk Re-volv'er. (*Optics.*) A stage disk mounted on a universal joint beneath the object-glass of a microscope, and intended to expose an object at various angles.

Op'ei-o-scope. An instrument for exhibiting the pulsations of sound. It consists of a tube from 1 to 2 inches in diameter, over one end of which is secured a thin membranous substance having a small mirror at its center. When a musical note is emitted into the open end of the tube, which is held so that the beam of light from the mirror may fall upon a white wall or screen, the image will vibrate, the vibrations differing for each tone. By a slight movement of the tube a series of sinuous lines is produced, forming either simple or compound waves according as the note is simple or compound.

O'pen-er. A machine for opening cotton taken from the bales in which it has been closely compacted. Is usually a box or casing with inwardly projecting blunt teeth, and with a screen-like bottom. A drum provided with blunt pins rotates within this casing, opens the cotton, and dirt falls through the grating. See OPENING-MACHINE.

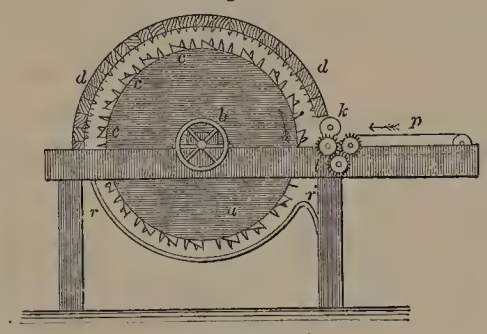
O'pen-ing-bit. A *broach* or *reamer.* A tapering tool with angular sides for widening an aperture.

O'pen-ing-knife. A blunt strong-bladed knife for opening oyster and fruit cans.

O'pen-ing-ma-chine'. A machine for loosening the tussocks of cotton as it comes from the bale, so that the offal and dust may be removed and the fibers parted. The machine has several forms, known as *willy, willower, devil, wolf, beating-machine, cotton-cleaner;* and when associated with a blast of air, as *blowing-machine, scutcher, blower,* and *spreader.*

It consists of a wooden drum *a*, having rows of iron spikes alternating on its circumference with upright iron ridges *c c c*, which prevent the cotton from passing through the machine too rapidly. The top of the drum is covered with a wooden lid *d d*,

Fig. 3401.



Opening-Machine.

consisting of *lags* of wood curved to the shape of the drum, and having similar spikes and ridges.

These lags are capable of being singly moved for the purpose of cleaning or repairing. The lower part of the drum is covered in with the brass wire-gauze *r*, which has an opening at *r'*, through which the cleaned cotton is removed, the dust and impurities falling through the gauze.

The machine is fed from the *feed-cloth p*, upon which the cotton is spread out by hand, and from which it is taken by the grooved nipping-rollers *k l*. The drum is driven by the pulley *b* at the rate of 400 to 450 revolutions per minute. The machine can prepare 1,000 to 1,200 pounds of cotton in a day.

O'pen Link. See OPEN RING.

Open Ring. (*Agriculture.*) A link with one side open, the ends lapping past each other, but not in contact.

Used for coupling the single-trees to the double-tree, and for analogous purposes in agriculture.

Also called *lap-ring,* as the ends lap over each other.

O'pen-sand Mold'ing. (*Founding.*) Heavy beams, foundations, and bed-plates are sometimes molded in the floor of the foundry, without any cope or top part. They are generally filled direct from the furnace. As such castings are never very sound, it is a method not often employed of late years.

Op'e-ra-glass. A binocular telescope of the kind invented by Galileo, and with which that philosopher first observed the planetary disks and Jupiter's four moons.

This has a plano-concave or double-concave eye-glass, so that the image is not inverted and little light is lost, thus securing great distinctness. See LENS.

The object-glasses are now made achromatic, and are adjusted simultaneously to the same focus by a milled-headed screw between the two tubes. These are usually made of hard rubber, ivory, papier-maché, or mother-of-pearl, so as to present an ornamental appearance, the use of the instrument being, in consequence of its limited magnifying power and narrow field, principally confined to the interior of buildings.

A larger and superior glass of similar appearance is used in military field service. (See FIELD-GLASS.) It is sometimes provided with a diagonal object-glass having a mirror within the tube at an angle of 45° with its axis, so as to show objects without apparently being directed toward them.

Op'e-ra-hat. A folding hat of felt, silk, or fur.

The *crush;* to fold flatly under the arm.

The *cocked;* the brim cocked up against the side-crown.

See G. Lloyd, English patent 4,900, 1834.
J. T. Tyler, 12,442, 1849.
Gibus, French patent, Fig. 17, Plate 22, Brevets d'Inventions, Vol. 111. Loi de '44.

Op'e-ram'e-ter. An attachment to a machine to indicate the number of rotations of a shaft. It consists of a train of gear-wheels and pinions inclosed in a box and connected to or moved by the rotating shaft. A finger on the dial-plate indicates the count.

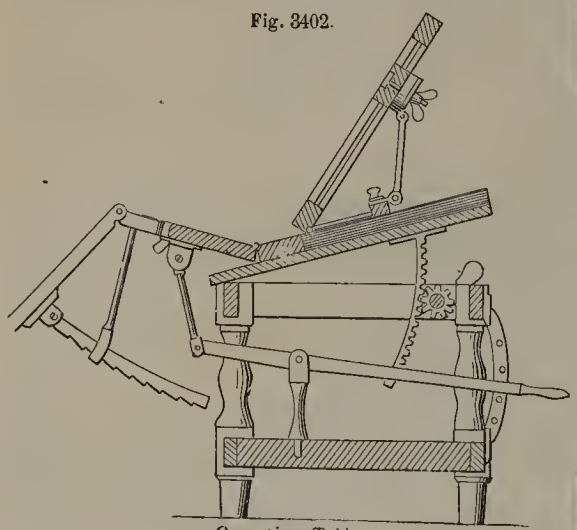
Operameters are used to count the revolutions of a shaft, axle, or wheel, the strokes of a piston, the copies from a printing-press, lengths of sheets from a Foundrinier or other paper-making machine or cloth measuring or printing machine.

A common form is the counter of a printing-press, which has a wheel for units, one for hundreds, and another for thousands. As the *fly* deposits a printed sheet, the unit-wheel moves forward one tooth. The complete revolution of this wheel moves the one of next higher order one tooth, and so on.

The accurate registration of the revolutions of a propeller or paddle-wheel is a matter of much importance to navigators, and many forms of operameters have been tried for this purpose. See REGISTER; ARITHMOMETER; SPEED-GAGE.

Op'er-at'ing-ta'ble. (*Surgical.*) One on which the patient is placed to expose prominently the portion to be operated upon. In the example, the table, back, thigh, and leg supports have individual vertical adjustments to support the patient in any position. The leg pieces have also a lateral adjustment to spread them apart for examinations and amputations, operations on the genitals, in lithotomy, applications of the speculum, etc.

Fig. 3402.



Operating-Table.

Oph'i-cleide. (*Music.*) A wind-instrument of metal, with keys and valves, and made *en suite;* that is, of various sizes and compass. (See HORN, *j*, Fig. 2563.) It is the largest brass wind-instrument of the trumpet species, and forms the bass to that class of instruments. Its compass is 3 octaves.

Ophicleides are the altos and basses of the bugle.

The *bass* ophicleide is written on the F-clef, and its compass is three octaves and one note. They are in two keys, C and B ♭.

The *alto* ophicleides are in F and E ♭; their compass is the same as the bass; they are written on the F-clef, like horns.

The *double-bass* ophicleides are in F and E ♭, a fifth below the bass ophicleides in C and B ♭.

The *bombardon* is a low-pitched instrument without keys and with three cylinders. It differs but little from the ophicleide.

Oph'thal-mo-di-as-tim'e-ter. (*Optics.*) An instrument contrived by Landsberg, a Hanoverian optician, and thus named by him, for adjusting the optical axes of lenses to the axis of vision. It consists of two tubes with adjustable plane glasses, each divided by a central line. On looking through this instrument at a mirror, each eye views its own image, and the glasses are adjusted until the line on the glass as viewed in the mirror is caused to bisect the pupil of the eye. — "Poggendorf Annalen," Vol. CX. p. 435.

Oph'thal-mom'e-ter. 1. (*Surgical.*) An instrument of the nature of compasses for measuring the capacity of the chambers of the eye in anatomical experiments.

2. (*Optics.*) An instrument invented by Helmholtz for ascertaining the true distance at which an object shall be viewed for the accommodation of each eye. It consists of two planes of glass at right angles to each other, and a sight-tube through which they and an object beyond them are viewed. By rotating the glasses on their common axis until the two images formed by reflection from their back surfaces coincide, the proper point of vision is ascertained. — "Poggendorf Ann.," Vol. CXI. p. 415.

Oph-thal'mo-scope. An instrument for inspecting the interior of the eye, invented by Professor H. Helmholtz, and described by him in 1851. He attributed the difficulty experienced in viewing images formed on the retina to the fact that the refractive humors of the eye cause it to be focused at the precise point *e* where the object forming the image is placed. In order to obviate the difficulty thus arising he employed a piece of plate-glass as a mirror, by which the rays from the object are at once both reflected and transmitted.

In the cut, *a* represents a candle, the rays of light from which, falling on the inclined reflector *b*, are thrown through the pupil of the patient's eye *c*, whose retina reflects the image back in the direction whence it was received; the transparent glass plate permitting it to be viewed by the eye *d* of the observer.

By this means the background of the eye is illuminated, enabling the observation of its delicate blood-vessels and tissues.

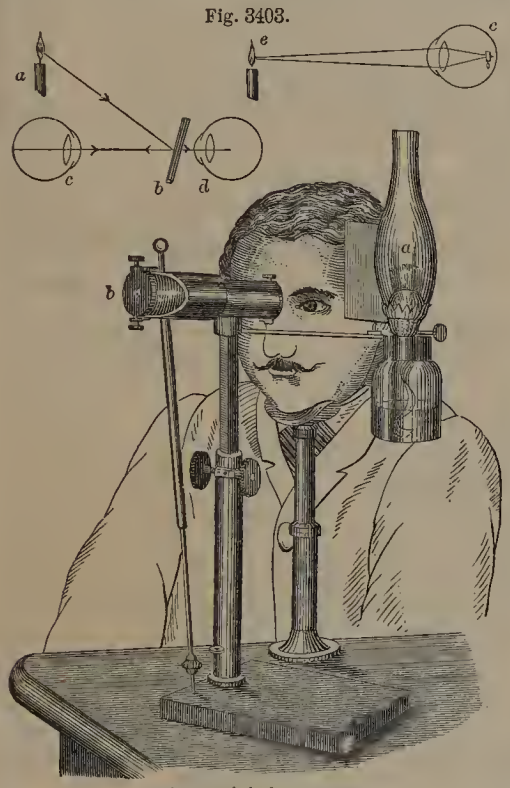
A great number of forms of this instrument are constructed. That of Dr. Liebrich is probably the simplest. It consists of a concave circular mirror

of about 1½ inches diameter and from 6 to 12 inches focus, having a central perforation, behind which is arranged a lens through which the eye, illuminated by the rays from a lamp reflected into it by a mirror, is viewed.

An instrument on the same principle, enabling a person to examine the interior of his own eye, is called an auto-ophthalmoscope. It is shown in the lower portion of the figure.

Dr. Knapp's instrument consists of two centrally perforated plates, connected by a handle, and having between them two disks each with a series of perforations near its periphery in which lenses are inserted, those in the one being convex and in the other concave, so as to form a varied series of magnifiers by turning the disk so as to bring different ones into coincidence over the central opening in the case. One side of the case has an annular concave mirror which reflects light into the eye while it is being examined by a magnifier or the naked

Fig. 3403.



Auto-ophthalmoscope.

eye, through the central opening. One of the openings in each disk is left unfilled, so that only a single lens, or no lens at all, may be used.

Oph-thal'mo-state. An instrument for holding the eye in a fixed position to facilitate operations. Such are the ophthalmostate of Jäger, the fine many-pointed forceps of Graife, etc. They have specific names, such as *fixation-forceps*, *iris-hook*, etc. *Ophthalmostatum.*

Oph'thal-mox-ys'trum. (*Surgical.*) A small brush with barbs like an ear of barley, to scarify the eyelids in cases of ophthalmia.

Op'si-om'e-ter. An instrument for measuring the limits of distinct vision in different individuals, for determining the focal length of lenses suited for remedying imperfect vision.

Lehot's device consists of a white thread placed on a narrow rule covered with black velvet, and having an arrangement for indicating the points at which the thread begins and ceases to be distinctly seen when held in a certain position with respect to the eye. See also Optometer.

Op'ti-cal In'stru-ments. The first ascertained optical fact was probably the propagation of light in straight lines.

Alhazen the Saracen, about A. D. 1100, was the first to determine that the retina is the seat of vision, and that light comes from external objects to the eye. Before his time it had been uniformly taught that rays issued from the eye and impinged upon objects. Euclid treated the subject on that principle.

Alhazen also explained the reason that "we see single when we use both eyes, because of the formation of visual images on symmetrical portions of the two retinas." — Draper.

He also wrote on the reflection and refraction of light. Knowing that the air increased in density toward the surface of the earth, he determined that the path of a ray of light through the atmosphere would be curvilinear, and the apparent position of the heavenly bodies an illusion. He also determined the hight of the atmosphere to be nearly 58½ miles. There were philosophers before Torricelli and Galileo.

The discovery of the lens is lost in antiquity, but in its early uses it was a microscope. (See Lens.) For telescopic purposes, a combination of lenses is required, — an objective and an eye-glass. This was invented about 1608 by Lippersheim and by Galileo. The latter turned it on the moon, and saw the shadows of the lunar mountains; on Jupiter, and discovered his satellites; on Saturn, and saw his bulging sides. He supposed the planet to be triple, as his telescope was not of sufficient power to define the ring. He afterward saw the phases of Venus and the spots on the sun. The reflecting telescope was invented in several forms, known as the Gregorian, Newtonian, etc. Then Newton made his discoveries in the reflection, refraction, inflections, and colors of light. Achromatism was discovered by Dolland; afterward polarization of light by double refraction; a century later polarization by reflection, by single refraction; depolarization, and many beautiful phenomena were observed, such as the irised rings, bright and black crosses in crystals, unannealed and compressed glass; then came the discovery that the colors of soap-bubbles were due to the thickness of the film, and this led to ascertaining the length of waves of light. The undulatory theory was suggested in 1664, and was held in abeyance by the supremacy of Newton's preferred material theory; the eye came to be considered as a camera, as described by Da Vinci; later we have reached the kaleidoscope the stereoscope, the photographic camera and processes, the compound and achromatic microscope, which is now working a revolution in anatomy and physiology. See under the following heads: —

Achromatic condenser.
Adapter.
Alidade.
Altarimeter.
Altazimuth instrument.
Altimeter.
Altiscope.
Altitude instrument.
Amici's prism.
Analyzer.
Animalcule cage.
Aperture.
Apomecometer.
Aquatic box.
Astigmatism apparatus.
Binocle.
Binocular glass.
Binocular microscope.
Binocular telescope.
Black-ground illuminator.
Burning glass or mirror.
Camera-lucida.
Camera-obscura.
Camera-photograph.
Camera-solar.
Catadioptric apparatus.
Catopter.
Catoptric cistula.
Catoptric dial.
Cloth-prover.
Collimator.
Compound microscope.
Compressorium.
Condenser.
Condensing-lens.
Dark-well.
Diagonal eye-piece.
Diamond-microscope.
Diaphragm.
Diaphragm-plate.
Diatom-prism.
Dichroscope.
Dioptra.
Dioptric light.
Dipleidoscope.
Dipping-tube.
Dissecting-microscope.
Double-bodied microscope.
Doublet.
Draw-tube.

Dynactinometer.
Dynameter.
Engiscope.
Erecting eye-piece.
Erecting-prism.
Erector.
Eye-glass.
Eye-rim.
Field-glass.
Finder.
Fishing-tube.
Florascope.
Folder.
Frog-plate
Goggles.
Graphic microscope.
Growing-slide.
Hand-magnifier
Heliometer.
Helioscope.
Heliostat.
Heliotrope.
Horizon. Artificial
Horizon-glass.
Illuminator.
Index-glass.
Indicator.
Iris-diaphragm.
Jointed microscope.
Kinescope.
Lens.
Level.
Lieberkuhns
Linen-prover
Live-box.
Live-trap.
Lorgnette.
Lucernal microscope.
Lunette.
Magnifying-glass
Megameter.
Megascope.
Meridiau-circle
Micrometer.
Microscope.
Microspectroscope.
Mirror.
Moderator.
Monocular microscope.
Multiplying-glass.
Nautical indicator
Negative eye-piece
Nobert's test-plate.
Nose-piece.
Object-finder
Octant.
Opaque-disk revolver
Opera-glass.
Opsiometer.
Optigraph.
Optometer.
Oxy-hydrogen microscope.
Parabolic illuminator.
Parabolic reflector.
Perspective-glass.
Polariscope.
Polarizer.
Polarizing-apparatus.
Polemoscope.
Positive eye-piece.
Prism.
Pseudoscope.
Quadrant.
Race-glass.
Ramsden's eye-piece.
Reading-glass.
Reflecting-circle.
Reflector.
Refracting-circle.
Repeating-circle.
'Scope.
Scotoscope.
Sector.
Sextant.
Side-reflector.
Slide.
Solar camera.
Solar eye-piece.
Solar microscope.
Spectroscope.
Spectacle-gage.
Spectacles.
Speculum.
Spherical mirror.
Spider-line
Spot-lens.
Spy-glass.
Stage.
Stage-micrometer.
Stage plate.
Stereoscope.
Striæ-detector.
Submarine telescope.
Teinoscope.
Teleiconograph.
Telemeter.
Telescope.
Terrestrial eye-piece.
Terrestrial refracting-telescope.
Theodolite.
Tourmaline.
Transit.
Triplet.
Universal instrument.
Vandkikkat.
Watchmaker's-glass.
White-cloud.
Zoöphyte-trough.

Op'ti-cal Square. A reflecting instrument used by surveyors and others for laying off lines at right angles to each other. It consists of a box containing two plane mirrors, set at an angle of 45° with each other, so that the image of an object reflected from one mirror to the other will form an angle of 90° with its true position, indicating the correct direction in which a perpendicular offset to the main line shall be measured. See also SURVEYING-CROSS.

Fig. 3404.

Optical Square.

Op'ti-cal Tel'e-graph. 1. A semaphoric telegraph. One whose signals are formed by altering the relative position of its indicators or by differing combinations of colors.

2. An electric telegraph of the needle or pointer class. See SEMAPHORE; ELECTRIC TELEGRAPH.

Op'ti-cal Toys, Scenes, and Effects. See under the following heads: —

Anorthoscope.
Astromara.
Camera-lucida.
Camera-obscura.
Chart.
Chromascope.
Chromatrope.
Cosmorama.
Cosmosphere.
Diorama.
Dissected map.
Dissolving-views.
Enorthoscope.
Georama.
Globe.
Horoscope.
Kaleidoscope.
Logotrope.
Magic lantern.
Map.
Marinorama.
Metamorphoscope.
Myriorama.
Myrioscope.
Orrery.
Panorama.
Panstereorama.
Phantascope.
Phantasmagoria.
Phenakistoscope.
Phosphoroscope.
Planctarium.
Planisphere.
Plot.
Pseudoscope.
Ribbou-map.
Section.
Sciopticon.
Stereomonoscope.
Stereoscope.
Stereopticon.
Stroboscope.
Tellurian.
Terrasphere.
Terrestrial globe.
Thaumatrope.
Zoetrope.

Op'ti-graph. (*Optics.*) A form of camera used for the purpose of copying landscapes. The rays from the object to be drawn are reflected from the plane-mirror *a* through the object-glass of the instrument to the speculum *c*, and thence through the eye-glass *d* to the eye at *e*. At *f* is a piece of parallel faced glass with a small dot on its center exactly in the focus of the eye-glass *d*.

Fig 3405.

Optigraph.

For use, the drawing-board to which the telescope is attached is clamped to a table, so that the surface of the mirror *a* may be nearly parallel to the object, and the pencil placed on any part of the paper where it is desired to commence.

The eye is then placed at the aperture of the eye-tube, and the mirror so inclined as to bring the small dot on *f* on some particular part of the image of the object, and the telescope adjusted to distinct vision. By moving the hand holding the pencil, the dot seen in the field of the telescope is passed over the outlines of the object, which are at the same time traced on the paper by the pencil.

The drawing may be made larger or smaller by varying the distance of the telescope from the paper.

Op-tom'e-ter. An instrument for trying the length of vision in adapting spectacles to the eye.

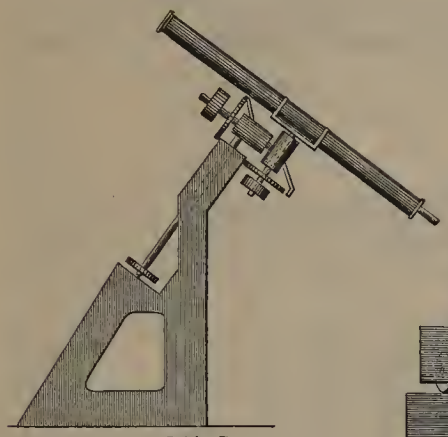
It consists of a rule to which a sliding upright is attached. This contains the test type, and is first held as near as possible to the cornea and afterward gradually removed until the nearest point of distinct vision is found. In another form, the rule is divided by a longitudinal line, which is viewed through two of several adjacent slits on the slider, when at the proper distance from the eye the line appears to form two intersecting lines. The distance of the apparent point of intersection is marked, indicating the focal distance required for the lens. See also OPSIOMETER.

O'pus. A reticulated masonry. See MASONRY.

Or'a-to-ry. (*Architecture.*) A room in a private house set apart for prayer. It differs from a chapel in not containing an altar, nor can mass be celebrated in it. — CANON.

Or'bit-sweep'er. Invented by Airy, to follow the inclined path of a comet or planet. It resembles a German equatorial, the polar axis of which is of greater length than usual, and which works for some distance at its upper end in a tubular bearing. The declination, or cross-axis, carries at one end a counterbalance, and at the other, not, as in the regular equatorial, a telescope, but a small trunk in which a second and smaller cross-axis turns; to one end of this is attached a counterbalance, and to the other end the telescope. By giving a proper position in rotation to the first cross-axis, any inclination of the second cross-axis to an astronomical meridian may be obtained, and the inclination of the circle in which the telescope will sweep will correspond and may be made to coincide with the definite line on the celes-

Fig. 3406.



Orbit-Sweeper.

tial sphere in which the comet is to be sought. — G. CHAMBERS.

Or'der. (*Architecture.*) The different modes of architectural treatment adopted by the ancients in constructing their public edifices and buildings of the higher class are denominated orders. They are usually separated into five, principally distinguished from each other by the proportions of their columns and the kind of capitals employed, but also by the relative proportions and decorative parts of their entablatures, as well as other minor features. They are known as the Doric, Ionic, Corinthian, Tuscan, and Composite.

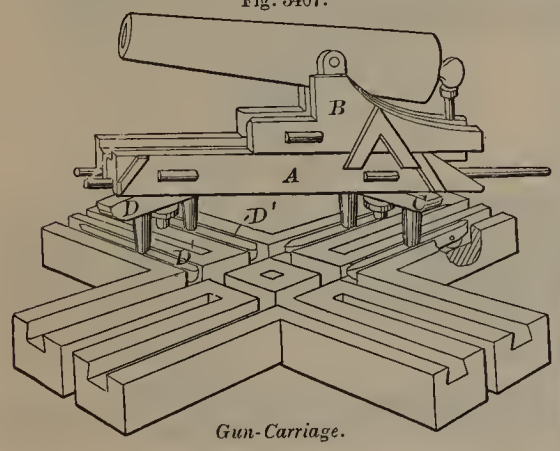
The Tuscan, so called, would, however, seem to be but a debased form of Doric, while the difference between the Corinthian and Composite is but slight, and not in favor of the latter, the copy.

They may be divided into three classes, according to their capitals; those of the Doric and Tuscan consisting simply of an echinus and abacus, the shaft of the Doric column being fluted and having no base, while that of the Tuscan is plain and provided with a base. The capital of the Ionic is distinguished by its volutes, the shaft is fluted and has a base. The Corinthian and Composite capitals are of the foliaged class, having volutes at the angles of the abacus, those of the Composite being the larger, leading to some change in the foliation; the shaft of each is fluted and has a base.

Ord'nance. A class of fire-arms too large to be fired from the person. See CANNON; MORTAR; BATTERY-GUN; HOWITZER; etc. See list under WEAPONS.

When hawks were supplanted by fire-arms, the names of the birds of prey were transferred to the new weapons.

Fig. 3407.

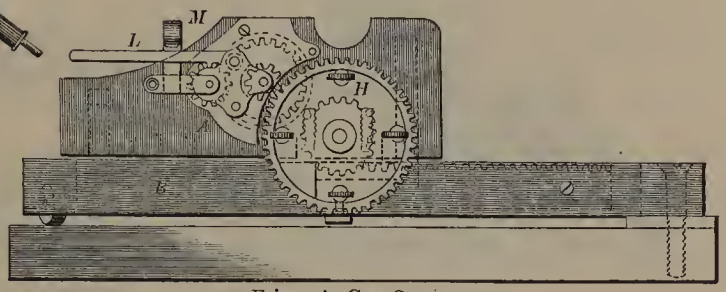


Gun-Carriage.

Mosquet, a sparrow-hawk, became mousquet.
Fançon, a hawk, was a heavy piece of orduance.
Terzuolo (Ital.), a hawk, was a small pistol, etc.

Fig. 3407 shows a form of timber carriage by which a gun may be trained to all points of the compass, without being pivoted or placed on a circular track. The foundation, or chassis, is composed of timbers framed together in the form of a cross, and having grooves *D' D'* cut in their upper surface. In these grooves the legs of bolsters *C D* run on casters, or slide on greased runners. The bolsters support the bed *A*, on which the carriage *B* slides out and in. The plan of mounting is adapted for use in earthworks and extemporized fortifications.

Fig. 3408.



Ericsson's Gun-Carriage.

Ericsson's gun-carriage, Fig. 3408, is for working guns on shipboard in rough weather, and is designed to check the movement of the carriage instantly, either in its recoil, or when swayed by the motion of the ship. *A* is the gun-carriage, and *B*, a slide-frame on which the carriage runs. *H* is a wheel with cogs on its periphery, which runs the gun out and in by means of gears worked by lever *L*. *M* is a nipper on the side of the carriage, which serves to lock the lever *L* and stop the motion of the gun in case of a lurch of the ship.

Several devices are in use to take up the recoil of guns, by rubber or spiral metallic springs, compressed air, etc.

Some of the gun-carriages devised by Captain Ericsson, and in use on the monitors, are so easy of operation that in case of necessity one man can manipulate a gun weighing 25 tons. See TURRET.

Stevens's mode of operating heavy guns, designed to obtain security for the gunners while loading, is by elevating the breech and depressing the muzzle, until the piece stands at an angle of 30°, or thereabouts. The charge is then inserted through a hole in the deck, if on shipboard, or from below the top of the parapet, if mounted in a fortification *en barbette*. For heavy guns the rammer is worked by steam-power.

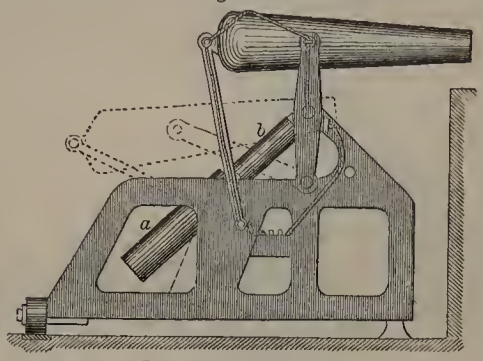
This plan of loading was tried on the "Naugatuck," a small iron-clad presented by Mr. Stevens to the United States government. The Parrott gun mounted on this vessel burst while she was engaged with the Confederate forts on James River. The disaster was supposed by some to be the result of the manner of loading, as affording the shot a chance to slip forward after being driven *home*.

Eads's system of working barbette-guns consists in removing the piece bodily below the parapet while loading, and only elevating it to position at the moment of firing.

Fig. 3409 shows a carriage for operating a gun in this manner. The recoil of the gun when fired compresses air in cylinder *a* by the pressure of piston *b*. When the piece is loaded, a valve is opened which allows the restoration of the gun by the expansion of the air.

Steam or water pressure may be substituted for that of compressed air. The carriage is trained hor-

Fig. 3409.

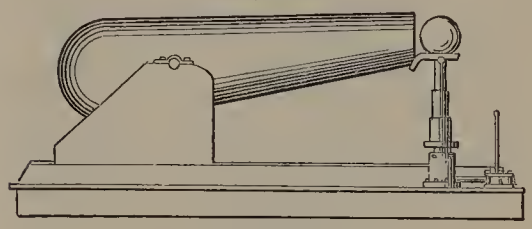


Eads's Gun-Carriage.

izontally in the usual manner, whether the gun be in a raised or depressed position.

Fig. 3410 is a plan of elevating heavy shot to the gun-muzzle. The ball is placed in a cradle upon a telescopic stem, which is extended by internal steam-

Fig. 3410.



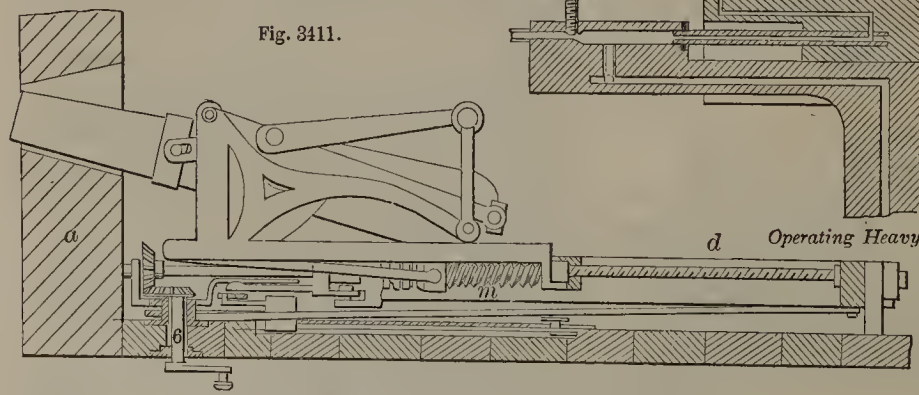
Ball-Elevator.

pressure from below. As it rises, the yoke on the cradle catches below the muzzle of the gun, the front stop is depressed, the pivoted cradle tilted, and the ball rolls into the bore of the gun.

Fig. 3411 is a plan for operating guns, in which the piece may swing about the muzzle, as a pivot, when the gun is in battery, so that a port-hole about the size of the muzzle may be sufficient.

In the figure, the chassis and carriage are moved by revolution of the crank-shaft 6. To elevate or depress the breech, the hollow screw-collar *m* on the shaft *d* is thrown into gear, and by lever connection the breech is swung upward. The collar *m* is left out of gear, and the chassis and carriage swung sidewise, still retaining the muzzle as a pivotal point.

Fig. 3411.

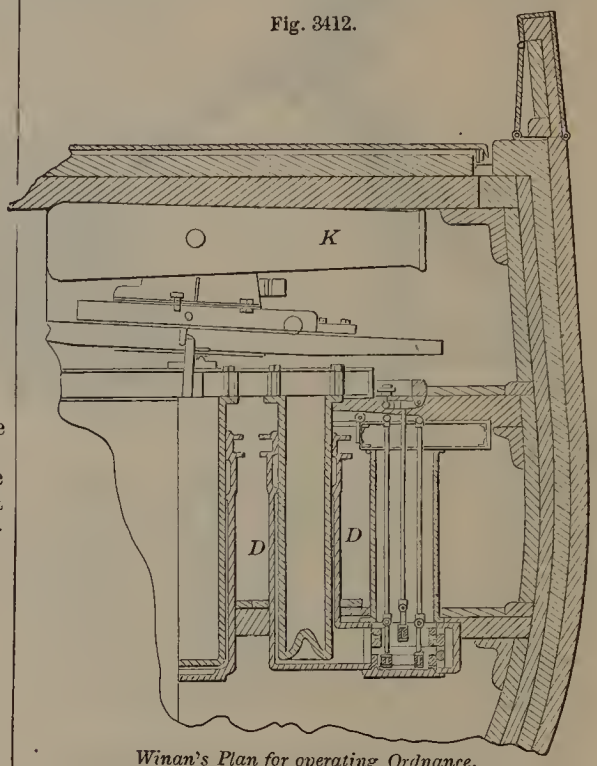


Eads's Ordnance-Operator (Minimum Port-Hole).

a is the shield through which the port-hole is made.

Winan's mode of loading guns on gunboats is illustrated in Fig. 3412. The gun-carriage is formed in two parts, the upper section swiveling upon the lower sections, and is supported on an adjustable

Fig. 3412.

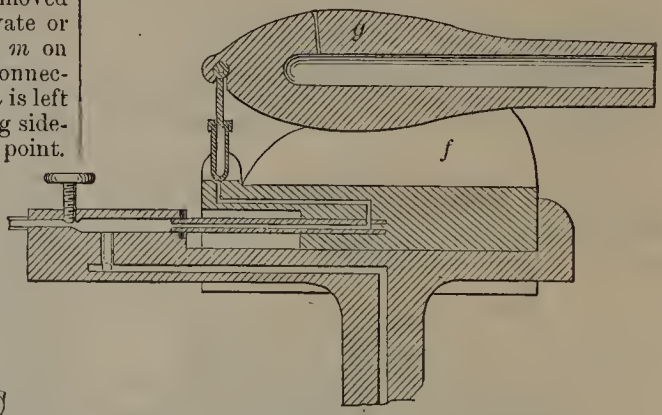


Winan's Plan for operating Ordnance.

chassis, the whole being raised and lowered by steam-power, and also supported on hydrostatic cylinders *D D*, which control the descent of the platform and its carriage. Sliding hatchways are opened and closed by the raising and lowering of the gun-platform. The vessel has no port-holes, and the gun *K* is lifted above the bulwarks when it is to be fired.

Moncrieff's counterpoise-carriage elevates the gun above its parapet by the weight of the front part of

Fig. 3413.



Operating Heavy Guns.

the cheeks. The upper and forward part of the carriage is made very heavy, and rocks in its seat when the gun recoils. See GUN-CARRIAGE.

Fig. 3413 shows a mode of operating heavy guns, invented by Mr. Perley of New York. The weight

of gun *g* and carriage *f* is borne by a hydraulic piston, working in a cylinder below. The recoil of carriage *f* expels water from the water-chamber at the rear, and when water is forced back into this chamber by the pumps, the gun is simultaneously run forward and the breech raised to its proper position for firing.

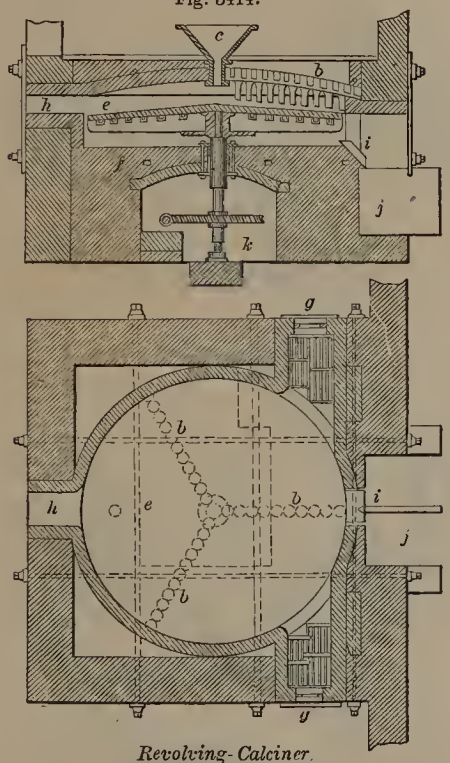
Ore-ap'pa-ra'tus. (*Metallurgy.*) The methods of treating ores are described under various heads, which are assembled under METALLURGY; FURNACE; MILL (which see). The methods are *dry*, *wet*, *hot*, etc. Otherwise classed, they may be *crushers*, *grinders*, *stamps*, *mills*, etc. Or they may be *sorters*, which act by wet or dry processes to save the more valuable from the coarser particles; such are *washers*, *jiggers*, *cradles*, *concentrators*, *separators*. Acting by heat, they may be *blast*, *smelting*, *calcining*, *desulphurizing*, *oxidizing*, *reducing*, *roasting* furnaces. Using quicksilver, they may be *pans*, *barrels*, *amalgamators*, *arrastras*, etc. See under these heads and the lists quoted above.

Ore-cal'cin-ing Fur'nace. A *roasting* furnace for ores. One in which ore is reduced to a friable state; the heat at the same time, as with some iron ores with argentiferous pyrites and many others, driving off certain volatile matters, such as sulphur, carbon, arsenic, phosphorus, antimony, etc.

An *oxidizing* furnace, which reduces the metal in the ore to a metallic calx.

Calcining or roasting furnaces are of various kinds: reverberatory, revolving on horizontal or vertical

Fig. 3414.



Revolving-Calciner.

axes. The furnace shown in Fig. 3414 is used at Constante, Spain, for the roasting of the argentiferous ore, which consists principally of antimonial sulphides of silver disseminated in gangues consisting chiefly of sulphate of baryta, and in combination with arsenic, iron pyrites, galena, and sulphide of copper. The hearth or table *c* is 14 feet in diameter, and makes four revolutions per hour, in which time the furnace consumes about 130 pounds of pine wood. *c* is the hopper through which the charge of ore and salt is fed. *b*, agitator-frames built into the masonry of the arch. The hearth *c* has a slightly conical surface, and is made of fire-brick set on end on a cast-iron shell. The bed *f* is also of refractory clay. The furnaces *g g* are on each side, and the products of combustion, after traversing the flue, pass by the duct *h* to the chimney. After calcination, the ores pass by the spout *i* to the chamber *j*. The stem of the hearth is stepped in a block on the floor of the crypt *k*, being revolved by the wheel and worm. See ROASTING-FURNACE; SILVER-MILL.

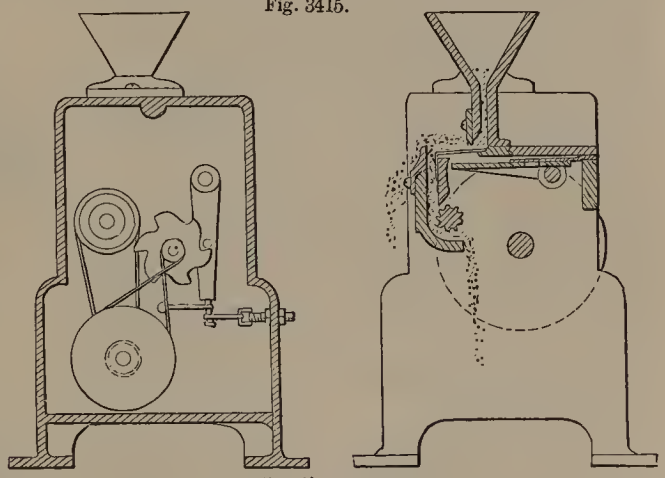
Ore-con'cen-tra'tor. (*Mining.*) A device to sort ores according to richness, or to separate the metallic portions of powdered ores from the gangue.

The processes are two, the *dry* and the *wet*.

The *dry* is illustrated by Krom's. (See CONCENTRATOR.) In this the powdered ore in a thin stratum is exposed in falling to a sheet of air in motion; this blows the particles to a greater or less distance, according to their comparative richness, the quantity of metal in each determining the relative weight. Heavy particles fall down in opposition to the blast; portions less weighty are driven somewhat out of their course and fall over a division board; light parts are blown away as dust. Screens aid in separating.

This device is shown in Fig. 3415, as also in Plate XXXIV. As each projection on the trip-wheel comes in contact with the pin, the lever is thrown back and the bellows carried down. The pin being passed, the rubber spring connecting the lever with another

Fig. 3415.



Ore-Concentrator.

fixed pin carries back the lever and bellows, repeating the operation for every tooth on the wheel.

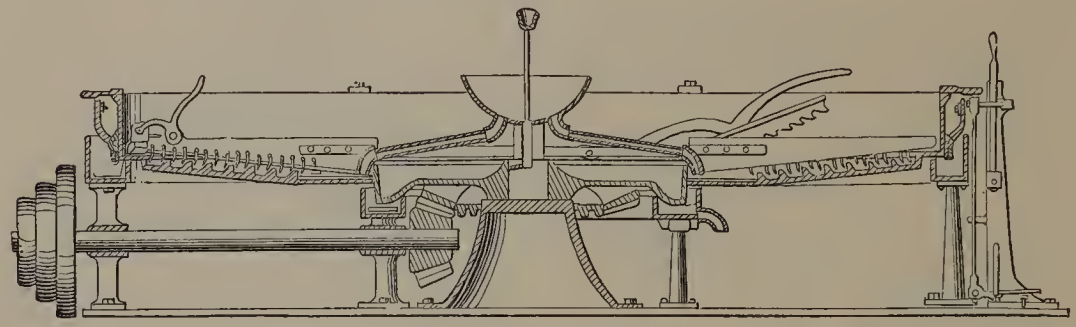
Plate XXXIV. represents a mill arranged for crushing and concentrating ores by Krom's dry process. The mill is preferably built on a hillside or steep slope, so that the ore may be delivered directly into the third story, where it is fed to the jaw-crusher *a*, by which it is broken into small fragments, and falls on to an inclined screen *b*, where that portion which has been crushed sufficiently fine is separated and conveyed by a chute to the elevator *c*; the coarser portion goes to the first pair of crushing-rolls *d*, where it is farther broken up, and, falling on a second screen *e*, the finer parts are carried through another chute to the elevator, the coarser pieces being transferred to the second crushing-rolls *f*, which complete the crushing, and deliver all the remainder to the elevator.

In this way the portions which have been broken sufficiently small are not subjected to the farther action of the rollers, the formation of an excess of

fine stuff is prevented, and a less amount, corresponding to the lesser capacity of each pair of rolls, which successively increase in fineness, remains to be treated.

The whole mass of broken ore is conveyed by the elevator to the upper floor of the building and delivered by the chute to the first screen *g*, where such as is still too coarse is conveyed by the pipe *h* back to the rolls to be recrushed, and that which passes the meshes of this screen falls into the second screen *i*; the pieces which fail to pass through the larger end of this screen constitute the first or coarsest

Fig. 3416.



Rotary Ore-Concentrator.

grade of ore for concentration, which flows into one of the bins *l*, three in number, on the third floor. The second grade is obtained from the end of the third screen *k*, while that which passes through its meshes constitutes the third or finest grade; each of these flows to its appropriate bin, whence it is delivered to separators *m*, one for each grade, on the floor below.

The concentrated ore and tailings from the separators are conducted by separate passages to the floor below, the former being received in bags or bins and the latter in cars preparatory to removal.

The dust made in crushing and separating is conducted through pipes leading to the screening-chamber, into the top of which enters the large pipe *n* of the exhaust-fan *o*, which causes a gentle draft from all parts of the building, so that the dust arising from the crushing as well as the screening is all ultimately conveyed to the settling-chamber *p*. The design is only to remove the flowing dust, leaving the heavier particles, which may be susceptible of farther concentration, behind. In the case, however, of gold and silver, the fine dust in the chamber may be preserved for future treatment if of sufficient value; otherwise it may be conducted directly out of the building.

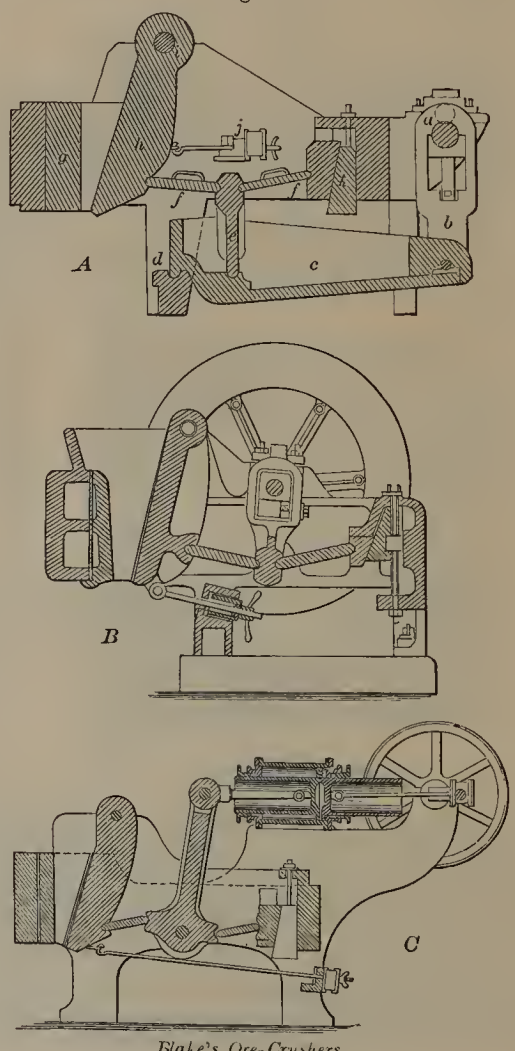
Fig. 3416 is an illustration of the *wet process* of concentrator. The circular, concave, grooved disk has a continuous rotary motion. The ore and water are received at the center and carried by centrifugal force to the periphery of the disk, the heavier particles settling in the riffles. The débris is separated by the current and constant agitation, is carried out by the sluice transversely across the disk to the center, and is discharged through openings into the stationary circular sluice below; the sulphurets are discharged by a plow at the periphery of the disk into another stationary circular sluice below.

In Varney's apparatus, the pulp is passed from the hopper to the pan, which is horizontally oscillated by a cam and recoil spring. By the inclination of the disk forming the floor of the pan, the motion, and the flow of the water, the lighter and heavier particles are assembled on the respective sides of the radial strips which divide the disk into sectional compartments. The trough beyond the periphery of the disk is divided in line with the strips, and has openings on each side of the divisions, which conduct the respective qualities, thus sorted by their relative gravities, by separate channels to their distinct receptacles, the lighter being discharged centrally to the waste-pipe, and the heavier particles of ore being collected in a circular series of boxes placed one below each discharge.

Other varieties might be cited.

Ore-crush'er. A mill for breaking ores into small pieces for farther treatment. Usually a preliminary breaking preparatory to *stamping*.

Fig. 3417.



Blake's Ore-Crushers.

Fig. 3417 shows three forms of the Blake ore and stone crusher. In each figure the parts are represented in position as they would be seen by removing one side of the frame *A*. *a* is the crank, *b* is a pitman or connecting rod which operates the lever *c*. This lever has its fulcrum on the frame at *d*. Upon the lever stands a vertical piece *e*, against the top of which the toggles *f f* have their bearings, forming an elbow or toggle-joint. *g* is the fixed jaw against which the stones are crushed. This is bedded in zinc against the end of the frame. *h* is the movable jaw, pivoted at *i* and swinging back and forth by every revolution of the crank. *j* is a rubber spring which opens the jaw, and *k* is a wedge which regulates the degree of closure of the jaw.

The jaws are generally set about 1½ inches apart at the bottom, and the vibration of the moving jaw amounts to about one fourth of an inch at the bottom, being, of course, much less toward the pivot. The full power of the engine is exerted to move the jaw through a very small space when the stone is large, and the force is exerted through a larger space as the pieces grow less in size.

B shows a form of the machine without the lever, the rod on the eccentric shaft being connected directly to the toggle-levers. This is the form of machine most in use in Europe.

C is a machine which has a steam-engine mounted on the frame. A piston-rod from the trunk-cylinder connects with the long arm of a rocking lever which is pivoted between the toggles.

Where large fragments of ore are to be crushed, as often happens in mining, a large crusher is sometimes introduced to break the rock into pieces of moderate size, which are then fed to smaller machines to complete the work. Crushers of this class are used in the Lake Superior copper-mines, and at Freiburg, Saxony.

The jaws of Blake's crushers are usually faced with case-hardened blocks of iron, which can be turned over when worn, and cheaply replaced when this is necessary. The jaws usually have coarse vertical furrows, the elevation on one opposite the depressions of the other, to prevent the passage of long, slim pieces of rock; but plain jaws may be used. See also ORE-MILL.

Ore-fur'nace. (*Metallurgy.*) A furnace for operating upon ores. The term is general, but the actual furnaces have specific names and various constructions, according to the metal, its gangue, the condition, etc. *Blast, calcining, desulphurizing, reducing, roasting, subliming* furnaces may be mentioned, but a list is given under FURNACE (which see). See also METALLURGY.

Ore-hearth. (*Metallurgy.*) A form of reducing-furnace which is without a dome, and known also as a *forge*. See lists under FURNACE; METALLURGY.

Or'e-ide. A factitious gold. See ORoIDE. See also ALLOYS.

Ore-mill. A machine for grinding ore, in order that by comminution the metallic portion may be separated from the gangue.

The plate on the next page shows several typical forms of *ore-mills*, known by various technical names, such as *grinders, disintegrators, crushers, stamps*, etc. Other forms not represented, or not as fully shown as desirable in this plate, may be found under the previous figure, the "Blake" crusher, and also under the heads of AMALGAMATOR, ARRASTRA, CHILIAN-MILL, PAN, STAMP, etc.

In Plate XXXV., next page, *A* is a form of mill known as the "Chilian." It rotates on its own axis, and also revolves around the central post, treading upon and grinding the ore in its path. See also CHILIAN-MILL.

B is a form of pulverizer, in which a pestle rolls on its axis and travels in a circular bed whose cross-section approaches the form of the rounded surface of the pestle.

C is a battery of two stamps, operated in the present example by cranks, pneumatic springs in the cylinders above the stamps giving a certain quality to the blow and recoil.

D is a form of crusher in which a heavy roller with circumferential grooves rotates and rolls in a rotating cylinder, the interior of which has corresponding interlocking ridges.

E has an eccentric toothed roller which has a reciprocating rotation.

F has two conical-faced disks, keyed to inclined shafts, having powerful set screws to adjust the width of space between the disks. The ore or stone is fed into a chute, and, falling between the inclined disks, is subjected to pressure as it passes into the gradually contracting space, and is thus crushed.

G has a concentric roller with teeth of varying sizes as the throat narrows, to bite upon the ore, which is gradually comminuted between the jaws as the roller is rocked.

H is a form like some kinds of grinding-mills for stock, excepting that the core and shell revolve in the same direction at different speeds.

I has a series of revolving cylinders with perforations and with interior corrugations; in the middle one of the series are balls. The material is fed through the trunnions and discharged through the holes in the cylinders.

J has a rocking bed and a heavy roller.

In *K* the ore enters the revolving cylinder from the hopper. The heavy inner cylinder rolls in and crushes the ore against the bottom of the outer one, which contains mercury. The discharge-cylinder is attached to the outer cylinder so as to catch any particles of metal that may pass over its edge. A current of water may flow through the apparatus.

L is a Whelpley and Storer's mill. It has a series of beaters *m m* which revolve in a casing and dash to pieces the blocks of copper ore which are placed in the hopper *o* and fed by the corrugated roller. A suction draft from the fan *n* removes the stuff when it is beaten into dust.

M has a wheel with hammers revolving a case with interior corrugations. A fan on the disk face of the wheel drives out the powdered ore.

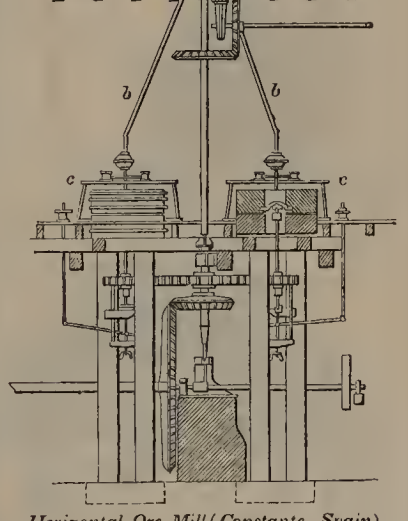
N is Howell and Hannay's machine for crushing quartz, boues, etc., by the percussive force of the rotating projector or by the impingement of the material against the inside of the case.

O is a form of the "Blake" crusher, in which the lower end of the moving jaw rests against the anti-friction roller, and its upper end receives motion by a cam turning in the rectangular opening. The concave faces of the jaws are thus made to roll together with a slight but powerful movement. See also Fig. 3417.

For list of machines and appliances in this line, see METALLURGY; MILLS.

The horizontal mill for grinding silver ores at Constante, Spain, is shown in Fig. 3418. The figure shows two mills, one in section; each has buhr stones, and is fed from a hopper *a* with ore ground so as to pass through a sieve of a gage of 100 openings to the square inch. Pipes *b b* lead the ore to the stones *c c*, which revolve in casings. The runners are suspended by balance-rynds upon the cock-heads of spindles, as in grain-mills, and are driven by a system of gearing below, which needs no particular description.

Fig. 3418.



Horizontal Ore-Mill (Constante, Spain).

Fig. 3419 is also a horizontal mill having a pair

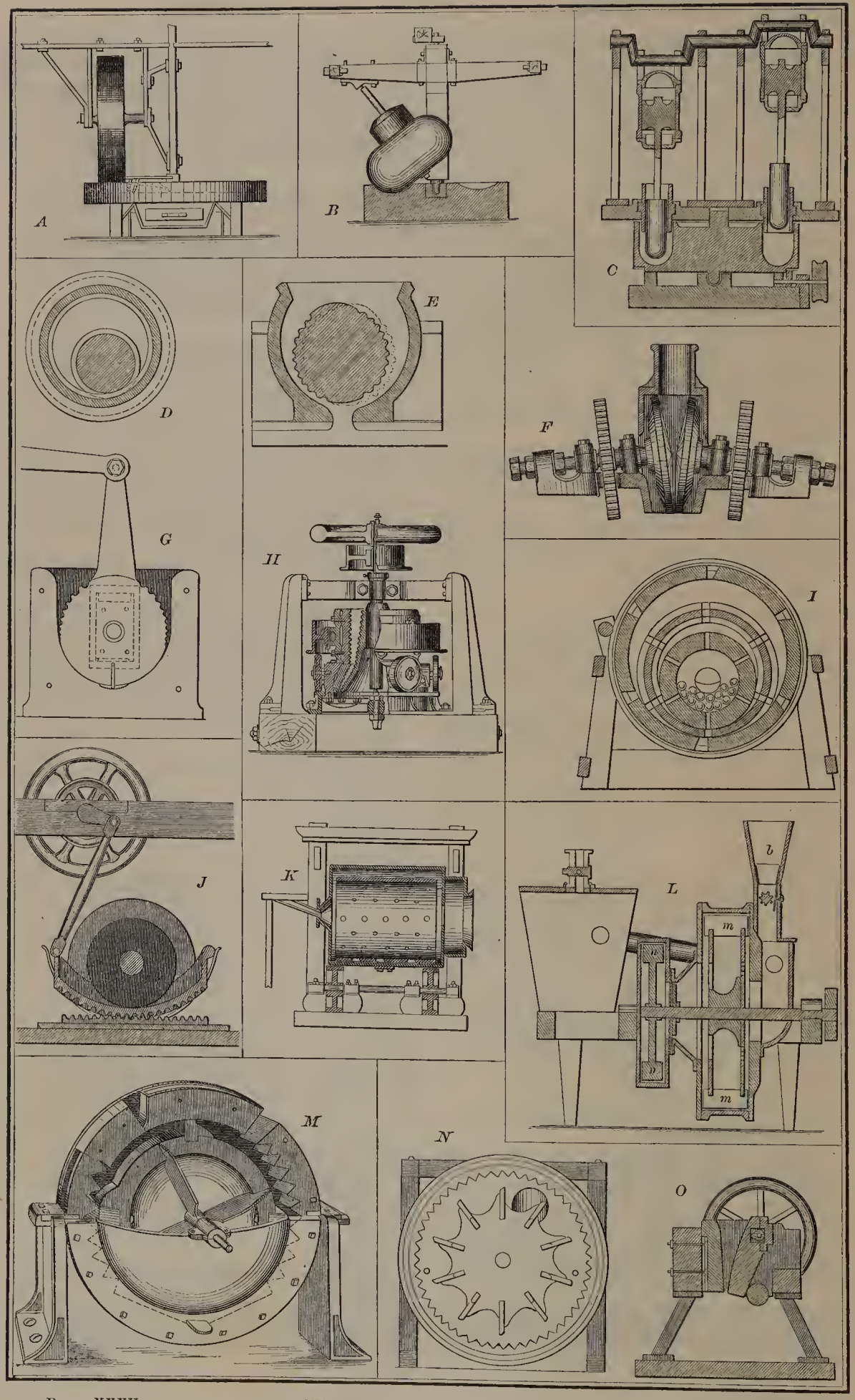
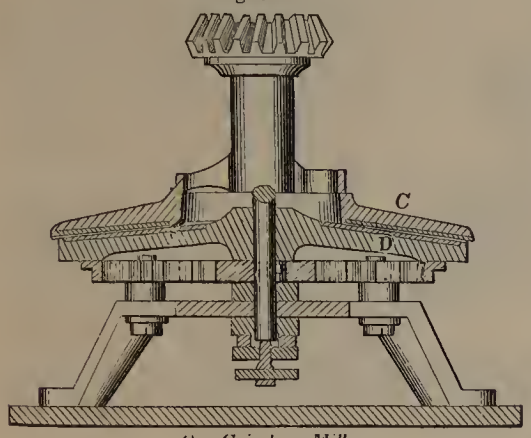


PLATE XXXV. ORE-MILLS OF VARIOUS KINDS.

See page 1569.

Fig. 3419.



Ore-Grinding Mill.

of slightly conical disks *C D* revolving in opposite directions.

Pliny says that "the ore is first broken up and washed, then roasted and ground to a fine powder." This was placed in a reducing-furnace to expel volatile metals, and the remainder was again ground and farther reduced in crucibles. He speaks also of breaking-machines used for crushing the silex as being shod with pieces of iron weighing 150 pounds. These were probably iron-shod stamps. See GOLD.

> "Whate'er is excellent in art proceeds
> From labor and endurance: deep the oak
> Must sink in stubborn earth its roots obscure,
> That hopes to lift its branches to the skies:
> Gold cannot gold appear, until man's toil
> Discloses wide the mountain's hidden ribs,
> And digs the dusky ore, and breaks and grinds
> Its gritty parts, and laves in limpid streams,
> With oft-repeated toil, and oft in fire
> The metal purifies: with the fatigue,
> And tedious process of its painful works,
> The lusty sicken, and the feeble die."
>
> DYER, *The Fleece*, 1757.

Ore-roast'ing Fur'nace. (*Metallurgy.*) One for heating powdered ores to drive off sulphur, arsenic, and other ingredients amenable to this treatment, and prepare the mineral for farther operations, by which the metallic portions are separated from the gangue.

Roasting-furnaces are of various kinds, some adapted to special metals. See COPPER FURNACE; ROASTING-FURNACE, etc., and list under FURNACE.

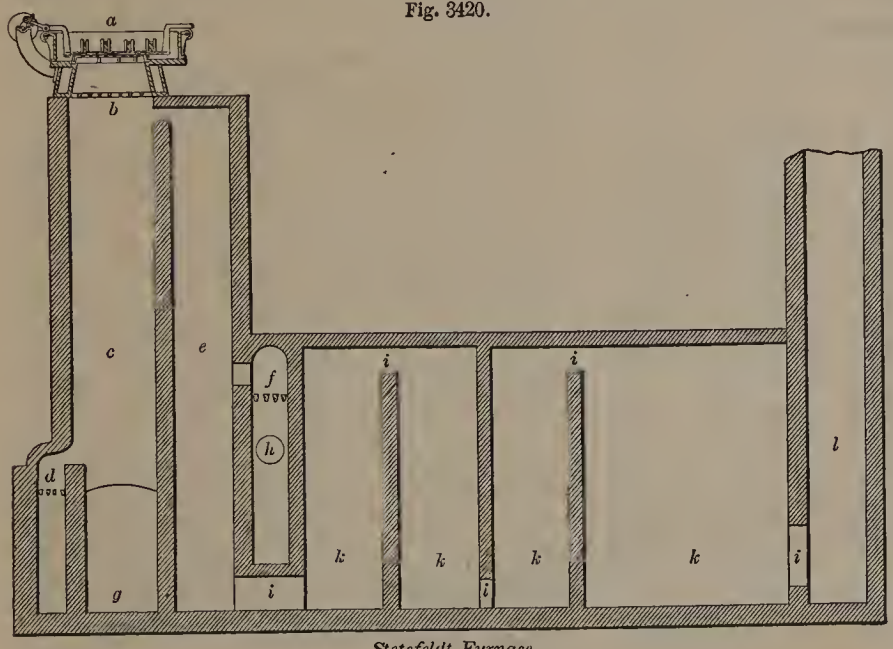
Others are known by their peculiar purpose, as *desulphurizing*, *calcining*, *oxidizing*, *reducing* furnaces, etc.

Others are known by their construction, as *reverberatory*, *horizontal*, *rotary*, *shaft* furnaces, etc.

The above are considered under their respective heads.

Fig. 3420 is a view of the Stetefeldt ore-roasting furnace, so much used in the silver districts, and shown under SILVER MILL in its relation and position to the *crusher*, *stamps*, and *amalgamator*. It is of the class known as a *shaft-furnace*, in which the finely powdered ore is mixed with certain chemical re-agents and dropped into the flame, which passes up the chimney. In the case, for instance, of operating upon the sulphides of silver mined in Utah, the ore which has been broken in the *crusher*, and reduced to powder by the stamps, is mixed in the latter with a certain percentage of salt, and then conveyed to the top of the furnace, where it is distributed by the feeder *a* in a shower of fine dust by the sieve *b*; falling down the shaft *c*, it is exposed to the full effect of the flames and heat rising from the furnace *d*, for which the shaft *c* forms a chimney. A double decomposition takes place in the shaft, the chlorine leaving the sodium and entering into combination with the silver to form chloride of silver, while the sulphur parts company with the silver and unites with the soda to form sulphate of soda, which is readily dissolved and runs away in the tailings. The heat of furnace *d* passes up the shaft *c* by way of an arch into descending flue *e*, where any metallic dust which is carried over is subjected to the action of the flame from the second furnace *f*; *h* is the air-opening for the supply of air to furnace *f*. The chambers *k k k*, connected by arches *i i i*, are for the collection of metallic dust, and are cleaned out from time to time. *l* is the chimney. The main body of the ore from the feeder *a* collects at the bottom of the shaft *c*, where it remains in a hot bed, and is removed at intervals to the damping-floor and the amalgamator. See SILVER-MILL.

Fig. 3420.

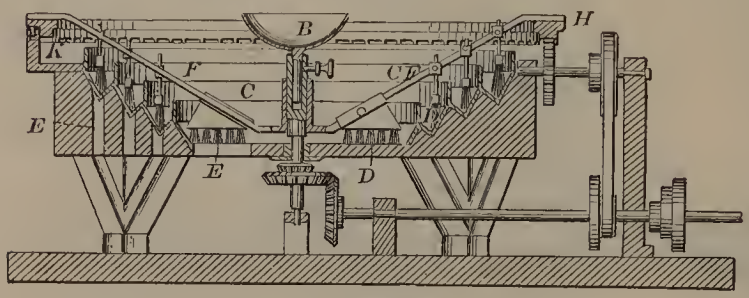


Stetefeldt Furnace.

Ore-sep'a-ra'tor. A general term which includes machines of various kinds for separating metallic ores from the gangue, after pulverization. They may be classed into wet and dry. Of the former are the *washers*, *frames*, *cradles*, *jigging-machines*, etc. Of the latter are *ore-concentrators*, etc. See also list under METALLURGY.

In Fig. 3421, the crushed material descending in regulated quantities from a vertical spout impinges on the rapidly rotating disk *B*, from which it is thrown off by centrifugal force, being at the same time sorted according to size and gravity,

Fig. 3421.

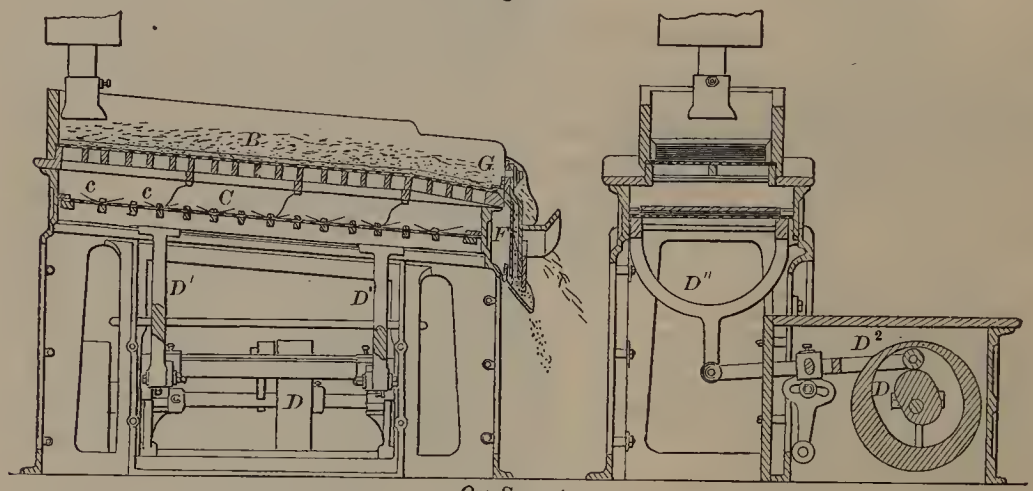


Ore-Separator.

the lighter portions falling farther from, and the heavier nearer to, the disk; the different sizes are received in the various grooves *C C* of the circular trough, and are swept into their appropriate chutes by brushes *D D E* attached to arms *F F*, which are fastened to a circular toothed rack *K H* rotated by a pinion driven by belt connection with the main shaft.

In Fig. 3422, the broken ore descends from a spout on to the inclined sieve *B*, through the meshes of which an upward current of air is passed from the bellows *C*. This is operated by the cam-wheel *D*, yokes *D' D' D''*, and levers D^2; these latter are adjustable on the wheel to regulate the working of the bellows, which is provided with valves *c c*, the openings of which may be varied to control the force of the blast, which requires to be stronger near the lower end, where the coarser particles collect. The various sizes are discharged through different chutes *F G*.

Fig. 3422.



Ore-Separator.

Ore-smelt'ing Fur'nace. One for reducing metal from its ores. See BLAST-FURNACE; IRON; SMELTING-FURNACE. See also lists under FURNACE; METALLURGY.

Ore-stamp. A means of crushing ore by shod beams vertically reciprocated. See STAMP-MILL.

Ore-wash'er. (*Metallurgy.*) A means of separating metal from ore after the latter has been reduced to powder. The slimes or metallic mud are agitated in *jiggers*, flowed over *frames* or *riffles*, exposed to a stream of water in *concentrators*, or otherwise treated with water so as to float off the lighter and less valuable portions, leaving the metal behind. See list of machines and processes under METALLURGY.

Gold is separated from broken quartz or from sand by similar methods. See GOLD-WASHER; GOLD-MINING.

Or'gan. (*Music.*) A musical instrument in which the notes are produced by pipes of different lengths, shapes, and materials, supplied with air by bellows and operated by keys which admit or cut off the supply.

The dimension of the instrument is designated by the number of feet of length that its largest pipe measures, forming the lowest note of the key-board. Thus, we speak of an organ of 32, 16, or 8 feet. An instrument which possesses *open flutes* of 32, 16, 8, and 4 feet, and a *principal* an octave above the latter, has a compass of 8 octaves. See MUSICAL INSTRUMENTS, Fig. 3263.

Large organs sometimes have five key-boards, one above another.

The first, nearest to the organist, is that of the *choir* organ.

The second, that of the *great* organ.

The third, the *bombarde* key-board.

The fourth, the *recitative* key-board.

The fifth, the *echo* key-board.

Below these is the *pedal key-board*, played by the feet. The music of the organ is sometimes written on three lines, the two upper ones for the hands and the under one for the pedal key-board.

The *organ* of Jubal (Gen. iv. 21), 3875 B. C., may be supposed to have been a mouth-organ or Pandean pipes. His name is associated with the invention of the harp and the organ, — stringed and wind instruments, — and the same connection of musical instruments is maintained in the Book of Job and the Psalms. In the latter case, the trumpet, harp (*of two kinds*), timbrel (*tambourine*), organ, and cymbal are referred to. The Greek word ὀργάνον, from which our word "organ" is derived, denoted an instrument of any kind, but was more particularly applied to musical instruments. According to Vitruvius, *organum* was a term applied to any instrument requiring skill in its use, while the *machina* merely required animal force for its operation.

The mouth-organ, or Pandean pipes, was expanded into an instrument resembling the bagpipes, in which the air for supplying the pipes producing the musical tones was blown by the performer.

In the "Spiritalia" of Hero of Alexandria, who

flourished 150 B. C., we find a description of an organ blown by the agency of a wind-mill which works the piston of the air-pump. Its invention is, perhaps, to be credited to Ctesibus of Alexandria, though it is likely that it was the result of the gradual improvement

Fig. 3423.

An Organ blown by Wind-Power, 150 B. C.

by various parties through the centuries. The reconstruction of it given in Fig. 3423 is by Woodcroft, from the text of the "Spiritalia." The descriptions of it by Athenæus, Vitruvius, and Claudian render it certain that the pipes were musical, and blown by the force of water, instead of expansible air-bellows.

Athenæus thus describes it: —

"And Alcides said: 'But this engine, the hydraulic organ, whether you choose to class it among stringed instruments or among wind instruments, is the invention of a fellow-countryman of mine, an Alexandrian, a barber by trade, and his name is Ctesibus.'

"And Aristocles reports this in his book on 'Choruses,' saying: 'The question is asked, whether the hydraulic organ is a stringed or a wind instrument. Now, Aristoxenus did not feel sure on this point; but it is said that Plato showed a certain notion of the invention, making a nightly clock like the hydraulic organ, being very like an enormous hour-glass, which, indeed, it resembles. It cannot, therefore, be considered a stringed instrument, and one to be played by touching. But perhaps it may be called a wind instrument, because the organ is inflated by the water; for the pipes are plunged down into the water, and when the water is agitated by a youth, as the axles penetrate through the whole organ, the pipes are inflated and emit a gentle and agreeable sound. And this organ is like a round altar, and they say was invented by Ctesibus the barber, who dwelt at that time in the territory of Aspendor, in the reign of the second Ptolemy, surnamed Euergetes, and they say that he was a very eminent man, and learnt a good deal from his wife Thais Trypho, in his dissertation upon flutes and organs, says that Ctesibus, the mechanician, wrote a book about the hydraulic.'" — From the "Deipnosophists," by Athenæus, A. D. 220.

A fuller description of an organ of this kind may be found in Vitruvius. An organ with pipes of varying length, and apparently about 10 feet high, is shown on a coin of the gentle Emperor Nero. He was much addicted to music, and is supposed to have also soothed his mind by the bagpipes. A Greek epigram in the Anthologia, attributed to the Emperor Julian, A. D. 364, has the following description: "I see reeds of a new species, the growth of another and a brazen soil, agitated by a blast rushing from a leathern cavern beneath their roots and producing melodious sounds, as the keys dance under the skillful fingering of a robust performer." The origin of the bellows organ would thus seem to have been known to the Greeks of the Eastern Empire.

Fig. 3424 shows several old methods adopted for supplying wind to the organ; the arrangement of the keys and the manner of manipulating them are also illustrated.

A is a representation by Father Kircher of a very primitive form of Hebrew organ, the "Macraphe d'Aruchin." In this, as in other of the earlier organs, a leathern bag served the purpose of the wind-chest.

B is copied from the sculptures on an obelisk at Constantinople, erected by Theodosius, who died A. D. 395.

C is a pneumatic organ of the tenth century; it is taken from an ancient psalter in the library of Trinity College, Cambridge.

D, from Gori's "Thesaurus Diptychorum," is said to have been taken from a manuscript of the time of

Fig. 3424.

Charlemagne. It represents King David seated on his throne, his scepter in one hand and a lyre in the other, on which he appears to be playing, accompanied by several instruments, including the organ.

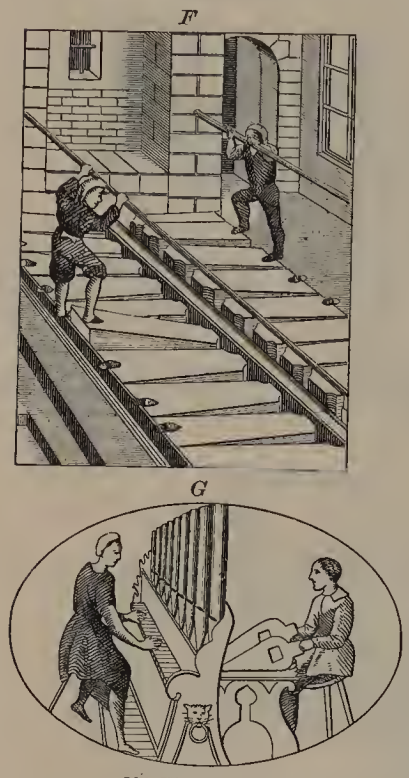
E is from an engraving in the "Theorca Musica" of Franchinus Gaffurius, printed at Milan, 1492.

F, from the "Theatrum Instrumentorum" of Prætorius, 1620, shows the ancient method of blowing. On each bellows is fixed a wooden shoe; the men who work them hold on to a horizontal bar, and, inserting their feet into a pair of the shoes, alternately raise one and depress the other.

G is what was formerly known as the "positive," in contradistinction to the "portative" organ. The lat-

Old-Time Organs.

Fig. 3425.



Old-Time Organs.

ter, as its name implies, was portable, being carried in processions by one person and played by another; it was also called the "regal" or "rigol." The former was fixed in position, and, when carried in a procession, it and its stand were placed on a car. An organ of this kind was afterward placed before the great organ in churches, the two constituting a single instrument, the "positive" being the origin of what has since been designated the *choir* organ.

The organ is said to have been applied to religious services in churches in 657, and first used in the Western churches in 658 by Pope Vitalianus; though they were, according to Julianus, a Spanish bishop, commonly used in Spain 200 years previous to this date.

In 757, the Emperor Constantine IV. presented an organ to King Pepin of France; and one, the work of a Saracen artist, was presented to his son Charlemagne by Haroun al Raschid; and, in 812, Louis le Débonnair built one on the Greek model at Aquisgrana, the modern Aix-la-Chapelle.

Several German organs were placed in Italian churches by John VIII., 872–882.

About 951, the abbey of Malmesbury and the cathedral of Winchester in England were provided with organs. At this time and for two centuries later, the compass was small, usually from 9 to 11 notes, the brass pipes harsh in tone and the machinery clumsy; the keys being 4 or 5 inches broad, and struck by the fist.

Gerbert of Auvergne, in his school at Rheims, had an organ played by steam. He was afterward made Pope by the Emperor Otho III., assuming the name of Sylvester II. He and his patron were poisoned by Italian intriguers about 1002. Gerbert introduced the Arabic numerals into Europe.

The organ of Winchester, probably placed there by St. Dunstan, had 26 pairs of bellows, 400 pipes, and required 70 men to work it.

The *key-board* is distinctly described at the close of the eleventh century. At this time a number of small bellows, 20 or more, were used, worked by men who held to a horizontal rail and operated the bellows with their feet, as at *F*, Fig. 3425. It is said that half-notes were invented at Venice in the twelfth century, but the earliest authentic example of their introduction was in the Halberstadt organ, built about 1360. The invention of the pedal is claimed for Bernhard, a German organist to the doge of Venice, 1470–80. He probably made some improvement in that appendage, but it appears to have been in use nearly a century previous.

The organ of Nuremberg had pipes from 16 to 32 feet long, A. D. 1468.

In 1596, the organ of Breslau had most of the now known stops.

It would seem that up to the fifteenth century organs were generally constructed by the monks, but about this period organ-builders by profession were to be found both in England and on the Continent. The earliest recorded in England was William Wotton, who, in 1587, agreed to make a pair of organs for Merton College, Oxford, for the sum of £28.

The German and Dutch builders appear to have taken the lead, and we find that, notwithstanding the strenuous opposition of Zuinglius and some of the early reformers, the German churches were, during the sixteenth century, generally provided with organs. During this century, the German builders introduced the *register* and the stopped pipe. The key-board also was extended to four octaves.

England, also, was well provided with artists of this class, and possessed some fine instruments.

In 1634, we are informed that the organ in the cathedral of Durham cost £1,000. Those of York, Litchfield, Hereford, Bristol, and other cathedral towns were also noted.

During the civil war, the Puritans, particularly the parliamentary soldiers, destroyed many fine organs, breaking them in pieces and selling the pipes for old metal. Few or none being built during this period, the art became almost forgotten in England, so that Pepys records, under date of July 8, 1660: "To White-Hall Chapel, where I got in with ease by going before the Lord Chancellor with Mr. Kipps. Here I heard very good musique, the first time that I ever remember to have heard the *organs* and singing men in surpliees in my life."

The class of native organ-builders having become almost extinct, inducements were offered to foreigners to settle in England. Prominent among these was Schmidt, generally known as Father Smith, who built the instrument referred to by Pepys. Among the instruments of this period was the organ of St. Paul's Cathedral, noted as being the source of much tribulation to Sir Christopher Wren, who considered that the harmony of his designs was spoiled by the "box of whistles." This instrument was nearly 30 feet high, 18 wide, and 8 deep.

About 1680, the *barrel-organ* used by itinerant musicians was introduced.

The early builders were fond of employing *outré* materials in their organs, and of decorating them with precious metals and stones, or with grotesque carvings; animals, birds, and angelic figures moved by mechanism were also introduced, the latter playing on the trumpet or beating big drums.

The old organ at Lynn, in Norfolk, had a figure of King David playing on the harp and larger than life, cut from the solid wood; likewise several moving figures, which beat time, etc.

We are told that the Emperor Theophilus, 829–41, had "two great gilded organs, embellished with precious stones and golden trees, on which a variety of little birds sat and sung, the wind being conveyed to them by concealed tubes."

The Duke of Mantua had an organ in which the pipes and other parts were made of alabaster. A pair of organs at Venice were made all of glass, and of the eight in the convent of the Escurial, near Madrid, one is said to be made of solid silver.

The devices required in order to make a pipe sound or *speak* are: the bellows, for supplying condensed air; a channel, for conducting it to the pipe; a valve or other contrivance, for admitting and cutting it off; and a lever, for opening and closing the valve.

The pipes are of two descriptions: the *mouth* or *flute* pipe

(technically called *flue*-pipe) and the *reed*-pipe, which are each farther divided into several varieties.

Mouth-pipes, so called from having a mouth and lips similar to those of the flageolet, are either of wood or metal. The latter are those observable at the front of the organ case, and are cylindrical in cross section. The wooden pipes are rectangular in section, the sides being in the proportion of 5 to 4; the interior is usually sized with glue. The upper end is open, or is closed by a tompion made air-tight by a leather covering. The other end is closed by a block to which three of the sides are glued, a narrow aperture being formed between the block and the front side, by beveling this side so as to have its sharp edge on the interior; this is called the *upper lip* or *wind-cutter*.

Another block is arranged so as to leave a narrow space between it and the block. The hollow cylinder, through which air from the bellows is supplied, is let into this block.

A mahogany cap, hollowed out on the inner side so as to leave the aperture free, is fastened to the front of the pipe below the mouth. The aperture between the cap and the block, called the *plate-of-wind*, admits the compressed air from the bellows in a thin stream, which, being forced against the mouth-piece or wind-cutter, produces a musical note determined in pitch by the length of the column of air set in motion. In order to *voice* the pipe, — that is, improve the tone, — the edge of the block opposite the upper lip is slightly pared away and serrated so as to divide the plate of wind and direct it against the inner edge of the lip.

The pitch of a note depends on the length of the pipe (see PIPE), while the tone or *timbre* depends on its diameter, its shape, or on the kind of wood employed; that yielded by pipes of hard woods, as mahogany, being more clear, while the softer woods yield a mellower sound.

The *chimney-top* pipe has a small open tube in the top-plate for the purpose of sharpening the note: a similar effect is sometimes produced by a hole in the tompion.

Metallic mouth-pipes are made conical at their lower termination, and where this cone and the cylindrical portion unite is an aperture occupied by a thick plate of soft metal, called the *languette*, nearly closing the tube, but leaving a small opening for the wind-plate, formed with the upper lip.

The thickness of the stream of air admitted to the pipe may be diminished by turning down a projecting exterior lip on the plate.

The *reed-pipe* is closed near the bottom by a solid plug, having apertures for the passage of the reed and its adjusting wire. The *reed* is a cylindrical or slightly tapering tube of brass, having a narrow longitudinal slit in front, covered by a thin plate of metal called the *tongue*, which is made fast to the reed at its upper part, but is free at the lower end The back part of the reed is cut off slanting at its lower termination, over which a piece of metal is soldered.

The *pitch* of the reed-pipe depends on the length of the tongue, which is adjusted by means of the *tuning-wire* above mentioned; the *quality* of tone depends on the pipe.

In the free reed of Grenié, invented many years ago, the tongue, instead of battering against the side of the reed, vibrates within the opening, producing a more uniform, sweet, and harmonious tone.

It also admits of the musical effects called *crescendo* and *diminuendo*, by varying the pressure of the air. The air escapes through tubes in the form of an inverted cone, whose upper portion is hemispherical and slit.

A *stop* consists of a series of pipes agreeing in quality of tone, or timbre, but differing in pitch. When any particular stop is drawn the keys will play on the corresponding set of pipes.

The stops are designated by figures or by words intended to be descriptive of the quality of sound, as *flute*, *oboe*, *vox humana*, etc. See STOP

Two or more key-boards are required to enable the performer to produce all the notes in an organ of more than one stop.

In a large organ the different series of stops are so arranged as to form three or four separate instruments, each having its own set of keys, wind-trunk, wind-chest, sound-board, etc. These have been distinguished by different names, as the *great-organ*, the *choir-organ*, and the *swell;* also the *pedal-organ*, or *foot-keys*, which act on the larger pipes.

Couplers are also brought into action at will, which connect the keys on different banks so as to make them act together when one is played. The effects are also varied by *tremulo* and *swell*, which give respectively quavering and rising and falling force of sound.

The feet of the pipes are inserted in the *upper* or *stock* boards, above the bearers and supported on *racks*, — thin boards mounted on pillars.

The pipes of the larger stops, however, take up so much space that they cannot be placed immediately over their proper groove, but they may be placed in any convenient position, even outside of the case, and air conveyed to them by means of grooves cut in the upper boards and covered with parchment, forming closed channels.

The key movement, in its simplest form, comprises: the *key*, a pivoted lever, which, being pressed down at one end causes the other end to raise the *sticker*, a small wooden rod depending from the end of a second lever above, which is thus depressed at its opposite end, drawing down the *pull-wire* and opening the *valve*.

This arrangement is, however, only applicable in case each key is opposite its own proper valve, a condition which can only apply in few instances. This difficulty is remedied by introducing a series of rollers above the secondary levers, whose ends are connected by wires with arms on the sides of the rollers; the other ends of these, on the same side, have also arms to which the wires controlling the valves are attached.

The foregoing description will give an idea of the general principles governing the construction of organs, though there are many mechanical details and improvements introduced into modern construction to which we have not space to refer.

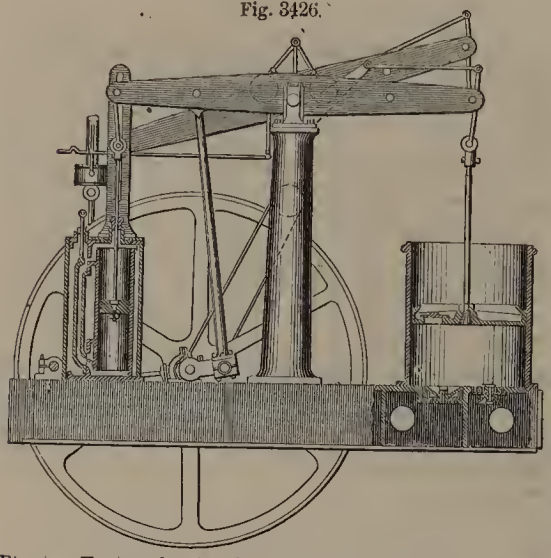
The *bellows* communicate with the *wind-chests*, which act as reservoirs and distribute the air to the different *pipes*, as the finger or foot *keys* are pressed down. The pressure of air is regulated by a weight on the upper part of the reservoir, usually about 15 pounds to the square foot. The different parts of the organ are now commonly supplied with air under different pressures, separate bellows being used for each pressure.

The *wind-chest* is an air-tight box communicating above with the *sound-board*, an oblong frame or box of wood divided by parallel strips into channels or compartments completely separated from each other. Holes corresponding with the number of ranks of pipes are bored through the upper part of the sound-board into each channel. Its lower side is covered with parchment or leather, except on that part where the channels communicate with the wind-chest and are closed by slack-valves opened by means of *pull down* wires operated by lever connection with the keys and brought back by a spring. On the upper side of the sound-board, at right angles to these channels, a set of grooves, corresponding in number to the number of stops, is formed by screwing down thin pieces of hard wood, termed *bearers*. These communicate through holes with each of the channels below, and each has a register or slide, a little thinner than the bearers, but exactly fitting the groove in length and width. The slides are pierced with holes corresponding in number and size with those of the sound-board, so that by drawing out or pushing in any particular slide, it is caused to open or close the holes in the sound-board, and supply or cut off the air from the range of pipes above it.

In organs of the largest class as formerly constructed the operation of the keys was a work requiring, in addition to musical skill, a large amount of hard bodily labor. It is said that the performer on the great Haarlem organ was obliged to strip preparatory to commencing his work, and retired covered with perspiration at the end of the hour's performance. This is one of the largest instruments in Europe, having 60 stops and 8,000 pipes. One at Seville has 5,300 pipes. The expenditure of wind varying greatly, according to the series of notes produced, the tension of the air supply was very different at different times, causing a variation in the purity of the tone and difficulty in opening the valves when under high pressure. These difficulties were remedied by the *pneumatic* lever of Barker, in which small subsidiary bellows operated by the movement of the key are employed to depress the wires by which the valves are opened.

Where an extraordinarily large supply of air is required, it may be furnished by blowers or bellows operated by hydraulic or steam power. Fig. 3426 illustrates the blowing-engine employed for the great organ at the Hall of Arts, South Kensington, London, England. It is a vertical beam-engine, having two steam cylinders of 7 inches diameter and 24 inches stroke, and two blowing cylinders of 24 inches diameter and 24 inches stroke. Its principal duty is to compress and attenuate air for blowing and for mechanical purposes, such as opening and closing the stops. The valves of the blowing cylinder are of india-rubber. The upward stroke exhausts the air from vacuum receivers, to which it is connected by zinc piping, and the down stroke exhausts the pressure receivers to which it is similarly connected. In addition to the ordinary governor, it has two throttle-valves connected respectively with the pressure and vacuum receivers, so that when the former is filled with air at 1½ pounds pressure above, and the latter with air at 1½ pounds pressure below, that of the atmosphere, both throttles are closed and the engine stops, thus regulating the supply according to the ever-varying requirements of the organ.

Fig. 3426.



Blowing-Engine for the Organ Royal Albert, Hall of Arts and Sciences, South Kensington, London.

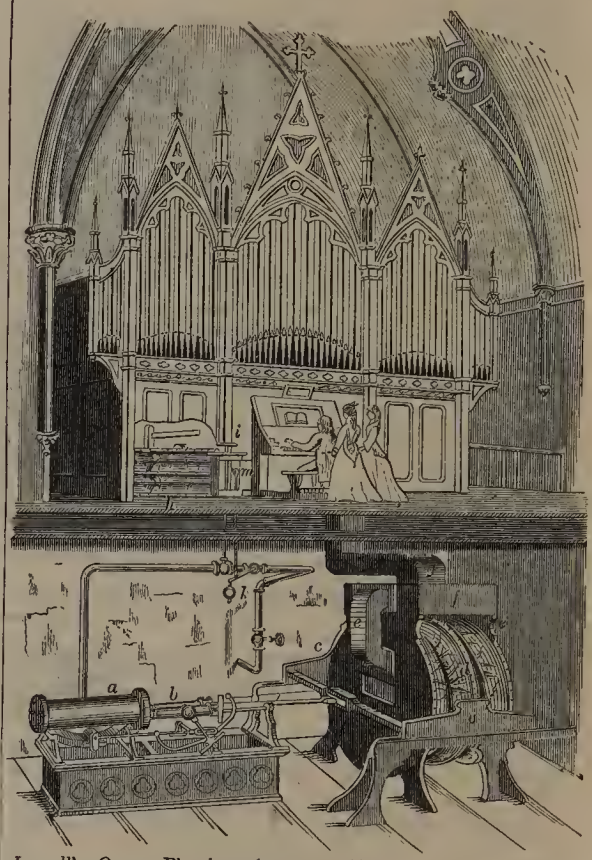
A horizontal engine of 13-horse power, driving a crank to which six large bellows are connected, furnishes compressed air to the reservoirs which supply the pipes.

This giant organ is 60 feet wide and 70 feet high; the four center pipes, which are over 40 feet long, weighing nearly a ton each. The instrument was erected by Mr. H. Willis, and, according to the "English Mechanic," is the finest in the world, having five claviers (four manuals, extending from C C to C in altissimo, and one pedal from C C C to G). The pedal-organ consists of 21 stops; the first manual clavier, or choir-organ, including the echo-organ, comprises 20 stops, all the pipes in which are of metal. The second clavier, or great-organ, contains 25 stops, only two of which have wooden pipes in the bass notes. The third clavier, or swell-organ, comprises 25 stops, and these are all, with the exception of the basses of two stops, of metal. The fourth clavier, or solo-organ, has 20 stops, making in all 111 stops; then there are 14 couplers and 32 combinations. The total number of pipes is close upon 9,000, and these range from 30 inches diameter down to the size of a straw, and from 40 feet in length down to 6 inches.

Fig. 3427 illustrates an organ provided with the hydraulic blowing apparatus designed by G. W. Lascell, Brooklyn, N. Y. *a* is the cylinder, the piston-rod of which *b* is attached to the cross-head of a reciprocating frame *e*, by which the movable diaphragm *d* of the double-acting bellows is operated, alternately forcing the air through the pipes *e e* into the wind-chest *f*, from which it is distributed by the trunk *g* to the organ bellows *h*. The wheel *i* is connected with a wire that controls the lever *k* of the governing valve of the water-supply pipe. As the bellows *h* becomes inflated, the block on its upper lid strikes against the lever *m*, closing partially or entirely the valve, and automatically regulating the supply of air to the demand. By means of a hand-wheel *i*, which can be conveniently reached by the organist, a valve *k* is opened or closed for admitting or cutting off the water supply. In this engine the crank is dispensed with, and the valve-gear so arranged as to prevent stoppage on the dead centers.

A number of reed instruments are called organs, being on the accordeon or melodeon principle, free reeds played by keys in one or more banks. Such are known as cabinet, parlor, and small choir organs.

Fig. 3427.



Lascell's Organ-Blowing Apparatus (Dr. Partridge's Church, Brooklyn, N. Y.).

Pipe organs are also made of a cabinet size. The *hand* or barrel organ is also a pipe organ in which the keys are moved by pins (staples) on a barrel moved by a crank, the arrangement of the pins being on a similar principle to that of a musical-box.

The *electric* organ is one in which the valves admitting air to the pipes are opened and closed by electro-magnetic action. The general arrangement is as follows: —

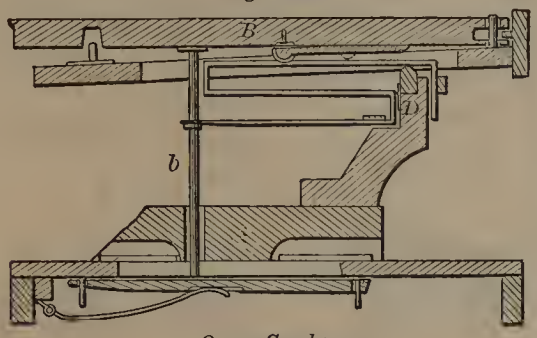
Each key has a separate insulated wire, the circuit through which is closed by depressing the key, causing a communicator to dip into a minute cup of mercury, the current thus established exciting a small electro-magnet that attracts a pallet or keeper, by which the valve is opened and remains so until the finger is withdrawn from the key, causing the pipe to *speak*. The battery employed is composed of glass vessels containing sulphate of mercury arranged on the upper surface of the bellows; when these rise, plates of zinc, each placed between two plates of gas-retort graphite, dip into the solution. No action is therefore exerted except at this time, and thus waste of battery power is avoided.

The arrangement admits of the key-board being placed in any convenient position, and at any distance from the instrument; the touch required for operating the keys is also much lighter than is required for an ordinary instrument.

Or'gan-coup'ler. (*Music.*) A device for connecting two sets of keys in an organ, so that by operating a lever or pedal each key when struck sounds the octave as well as its own note.

In Fig. 3428 the coupler is a bent wire, having a collar at one end which slips over the tracker-pin *b* that connects the key *B* and its valve. By a movement of the lever *D* the coupler may be caused to

Fig. 3428.



Organ-Coupler.

sound a note an octave higher than that of the key *B*, or may be thrown out of adjustment, so that only the note proper to that key will be produced.

Or'gan-die. (*Fabric.*) Fine Swiss figured muslin for ladies' summer wear.

Or'gan-har-mon'i-con. (*Music.*) A large *harmonium* or cabinet organ.

Or'gan-loft. (*Building.*) That part of a church designed for receiving the organ and its appurtenances. Usually an end gallery is chosen for this purpose. In ancient buildings it was customary to place it at one side of the choir, usually the north.

Or'gan-pipe. (*Music.*) A tube in which air is vibrated to produce a musical sound.

The organ-pipe is of two kinds: —

1. The *flute* or *mouth* pipe.
2. The *reed* pipe. See PIPE.

"The vibrating body in the organ-pipe is not the pipe, but the air contained in it. An agitation produced in the air at one end of the pipe is communicated to the other end, and reflected backwards and forwards from end to end, producing isochronous (or equal-timed) impulses, the frequency of which depends entirely on the *length* of the pipe. Hence, all organ-pipes of the same length yield the same note as to *pitch*, its quality only being affected by the form or material of the pipe. It will thus be at once perceived that the lowest C (the waves of which are 64 feet long) requires a pipe of 32 feet to produce it; and that all notes, from this to the shrillest whistle, are easily calculated, by dividing 550 feet by the length of the pipe." — TOMLINSON.

Fig. 3429 illustrates an organ-pipe of the *mouth* or *flute* kind. On opening the proper valve by depressing its key, the compressed air from the wind-chest passes through the tube *a* into the chamber *b*, and is directed with some force through a narrow slit against the sharp edge *c*, formed by beveling one of the sides of the pipe.

Fig. 3429.

Organ-Pipe.

In the *reed*-pipe the vibration of the air is caused by a metallic tongue affixed or inserted in the *reed*, a tube having a slit throughout its length, and fixed within the pipe.

Or'gan-zine. *a.* A silk thread made of several *singles*, *thrown* together. *Thrown-silk.*

b. Silk fabric made of such thread.

A *single* is a reel thread twisted. Several singles are twisted together in a direction the reverse of that of the singles, making *thrown-silk*. The *single* receives a twist to the left, is *doubled*, — that is, united with others, — and the combined threads are twisted to the right. *Organzine* is therefore *double-twisted thrown-singles.*

Orgues. 1. (*Fortification.*) Timbers shod with iron so suspended as to be dropped upon an enemy passing through a breach or gateway.

2. An arrangement of a number of parallel musket-barrels, so placed as to be fired simultaneously by a train of powder. Such was the weapon of Fieschi who fired at Louis Philippe, and it may be held to be the predecessor of the MITRAILLEUR (which see).

O'ri-el. 1. The bow-window of English domestic architecture. Sometimes it is of two stories. Sometimes it does not reach the ground, but is supported by corbels.

2. A recess within a building, as a window-way, closet, or chamber.

O'ri-en-ta'tion. The placing with an eastern aspect or presentation. From Lat. *oriens;* Sc. *sol*, rising.

(*Surveying.*) The determination of the east point in taking bearings.

(*Architecture.*) The placing of a church so that its chancel is toward the east.

O'ri-ent-a'tor. (*Surveying.*) An instrument used in regulating the ground plan of a church, so as to present the chancel to the east.

O-ril'lon. 1. (*Fortification.*) A curved projection formed by the face of a bastion overlapping the end of the flank, intended to protect the latter from oblique fire.

2. An earthen mound faced with brick.

Or'leans Cloth. (*Fabric.*) A ladies' dress-goods, having a cotton chain and woolen filling. It has a self color and highly finished surface.

Or'lo. (*Music.*) A Spanish wind-instrument.

Or'lop. (*Shipwrighting.*) *Orlop-deck, orlop-beams,* are, respectively, the lowest deck of a ship, or beams occupying the corresponding position. The deck is below the water-line, and may be occupied by the magazine, cock-pit, and for stores.

Or'mo-lu'. (*Alloy.*) *a.* A brass used for cheap jewelry. Copper, 48; zinc, 52.

b. Bronze or copper gilt also goes by this name. See ALLOY.

Or'mo-lu'-var'nish. An imitation gold varnish.

O'ro-ide. (*Alloy.*) An alloy resembling gold in appearance. One formula for its production is, —

Copper	100
Zinc or tin	17
Magnesia	6
Sal-ammonia	3.6
Quicklime	.12
Tartar of commerce	9

The other ingredients are added in small quantities to the fused copper and stirred in; the zinc last. Fusion is then maintained for about 35 minutes, when the dross is skimmed off, leaving the alloy fit for use. It is largely employed in the manufacture of cheap watch-cases.

Another formula is, -

Copper	79.9
Zinc	13.05
Nickel	6.09
Iron	.28
Tin	.09

The latter two are, perhaps, merely accidental ingredients. See ALLOY.

Or'phe-on. (*Music.*) A musical instrument of the melodeon order.

Or're-ry. A planetary machine to illustrate and explain the motions of the heavenly bodies. Its invention appears to have been coëval with the construction of the clepsydra and other horological automata. It was so called from the Earl of Orrery, who bore the expense of one constructed in 1715 by Rowley, after a pattern devised by the clockmaker George Graham. See PLANETARIUM; TELLURIAN.

The heliocentric theory was held by the ancient Egyptians, and taught by them to Pythagoras. The theory did not flourish in Greece. Plato mentions

it. A few scholars, like Nicolas (probably of Laodicea, fourth century A. D.), entertained it during the vast intervening period, and it was eventually revived by Copernicus.

When the Spaniards conquered Peru, they found the natives in possession of the true theory, considering the sun the center of our system.

The Chinese annals state that Tsi-ang-nung, in the reign of Shu-en-ti (126 – 145 A. D.), made an orrery to represent the apparent motion of the heavenly bodies round the earth, the instrument being kept in motion by the dropping of water from a clepsydra. There is a reference also to a similar instrument in the third century.

A planetarium is described in a letter from Angelo Politiano to his friend Francesco Casa, as seen by the former at Florence in the fifteenth century. The inventor was one Lorenzo of Florence, and the apparatus was constructed to illustrate the Ptolemaic theory of the heavens. The various parts were moved by trains of cog-wheels. Life of A. Politiano, published by Cadell and Davis, London, about 1800.

A planetary clock was made by Finee, 1553, and a planetarium by De Rheita in 1650.

Or'se-dew. Leaf metal of bronze. Dutch metal.

Or'tho-graph. A drawing representing a structure in *elevation*, external or internal. The internal *orthograph* is usually termed a vertical section or *sciagraph*.

The ground plan is the *ichnograph*.

The view of the whole building, the *scenograph*.

Or-tho-scop'ic Lens. (*Optics.*) An arrangement of two achromatic compound lenses, separated by an interval.

Or-tho-pæ'dic Ap-pa-ra'tus. (*Surgical.*) A device to correct the deformities of children, such as curved spine, club-foot, etc. See CLUB-FOOT APPARATUS.

Os'cil-lat-ing-cyl'in-der Steam-en'gine. (*Steam.*) A simple form of engine, in which the cylinder rocks on trunnions and the piston-rod connects directly to the crank. It was invented by James Watt, and was brought into use by Maudslay. Watt's model, made at Soho in 1763, was exhibited at the London Exhibition of 1851.

Witty of Hull patented the oscillating cylinder in England in 1813. English patent, June 5.

Goldsworth Gurney was in some way associated with the improvement of it, and has been credited with the invention.

It was introduced by those two famous makers of marine and river engines, Maudslay and Field and Penn and Sons.

This engine has a cylinder mounted on gudgeons or trunnions, generally near the middle of its length, on which it is capable of swaying to and fro through a small arc, so as to enable the piston-rod to follow the movements of the crank, to which it is directly attached without the intervention of a connecting-rod. This construction is economical of space and weight.

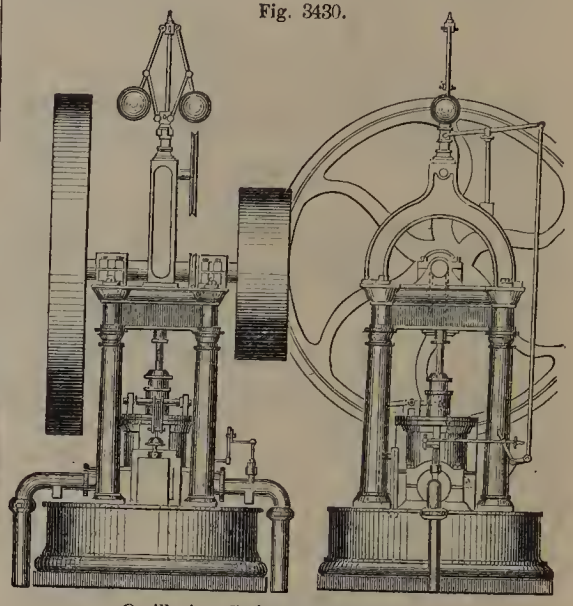
The trunnions are hollow, and are connected by steam-tight joints, one with a steam-pipe leading from the boiler, the other with an exhaust-pipe leading to the condenser.

The *valve-chest* oscillates with the cylinder.

Various arrangements are used to adapt the valve gearing to the oscillating motion of the cylinder and valve-chest. One of the simplest is to communicate motion from the eccentric to a sliding rod, on which is a *cross-head* of the form of an arc of a circle described about the axis of the trunnions, when the valve is in its middle position and having in it a slot of the same figure; in that slot is a slider attached to the end of a lever arm projecting from a rocking-shaft attached to the cylinder; another arm projecting from that shaft moves the slide-valve rod.

Another form of valve common in engines of this

Fig. 3430.



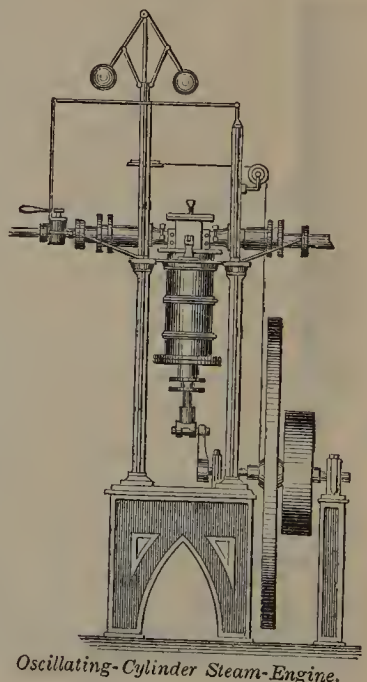
Oscillating-Cylinder Steam-Engine.

class is the trunnion-valve either of a disk form or having the shape of a frustum of a cone, in either case one portion of the valve having a rotary reciprocation derived from the oscillations of the cylinder.

Fig. 3430 is an engine of this character for land use. The power may be communicated by a leather band over a pulley fixed on the axle of the fly-wheel, or by means of a spur-wheel and pinion. The steam is admitted through the hollow axle on one side, and withdrawn through a similar hollow axle at the opposite side of the cylinder.

The figure gives side and front elevations, respectively. The top works are supported by a four-column frame.

Fig. 3431.

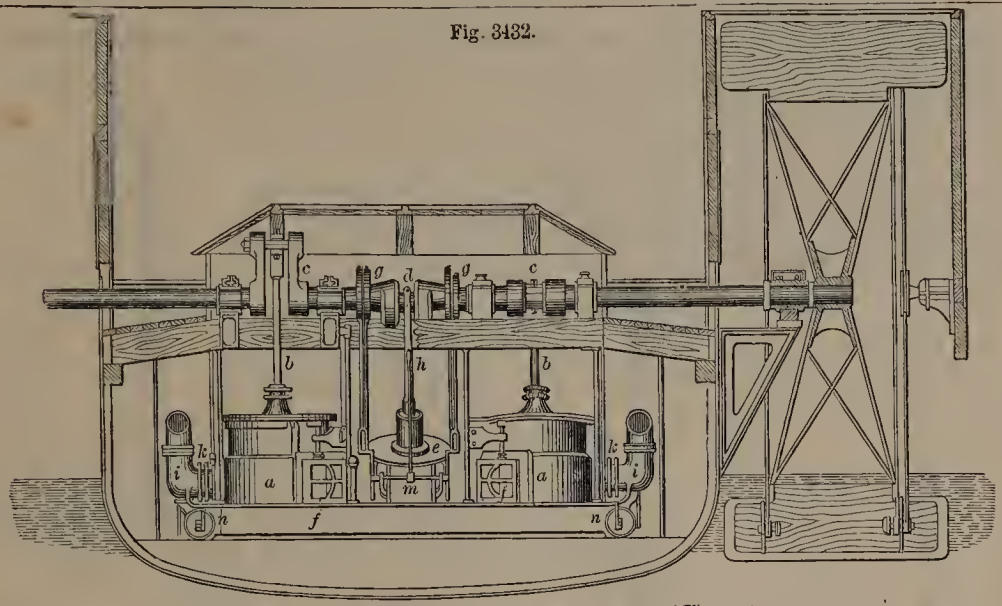


Oscillating-Cylinder Steam-Engine.

Fig. 3431 is another form of oscillating-cylinder steam-engine, known as Joyce's pendulous high-pressure engine. The cylinder is inverted and oscillates on its trunnions after the manner of a pendulum. The piston-rod is connected directly to the crank. See also OSCILLATING-PISTON STEAM-ENGINE.

Fig. 3432 is a transverse view of a low-draft river steamboat with a pair of oscillating engines and feath-

Fig. 3432.



Oscillating Engine on Low-Draft River Steamer (Thames).

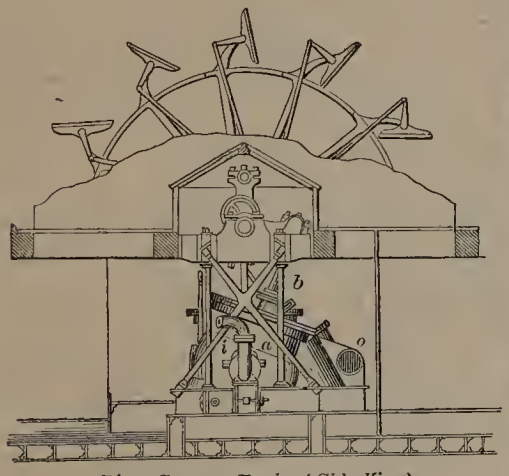
ering paddle-wheels. Fig. 3433 is a side view, showing one cylinder inclined, and the upper portion of the wheel with its floats in their changeable positions. The engines are coupled by an intermediate shaft having a crank which operates one or more air-pumps.

a a are the steam-cylinders; *b b*, the piston-rods, connected immediately with the cranks *c c*; *d*, a crank in the intermediate shaft, working the piston-bucket of the air-pump *e*; *f f* are slide-valves regulating the admission of steam to the cylinders; *g g*, double eccentrics on the intermediate shaft, operating the valves *f f*, enabling a link motion to be employed.

h is a handle by which the engines may be stopped, started, or reversed.

i i are steam-pipes leading to the trunnions *k k*,

Fig. 3433.



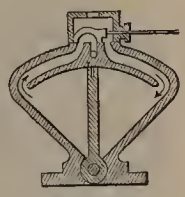
River Steamer Engine (Side View).

on which and on other trunnions connected with the pipe *m* the cylinders oscillate; *n n* are pumps, the pistons of which are attached to the trunnions and worked by the oscillations of the cylinders; *o*, the waste-water pipe from the condenser.

Os'cil-lat-ing-pis'ton Steam-en'gine. A form of steam-engine in which the piston oscillates in a sector-shaped chamber. By means of a slide or other valve the steam is admitted to alternate sides of the piston, which imparts a rotary reciprocation to the rock-shaft.

The engine (Fig. 3435) has a piston planted on an axis and has an oscillation in a vertical plane.

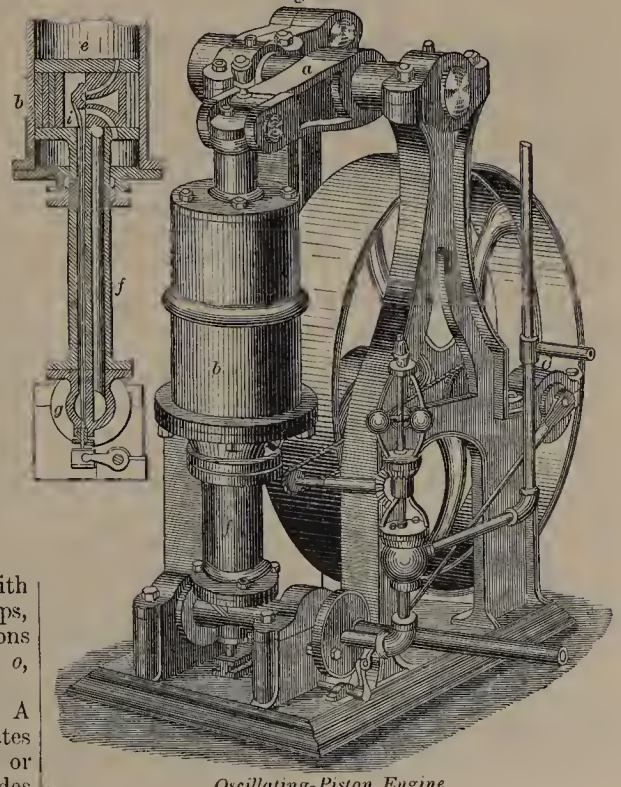
Fig. 3434.



Oscillating-Piston Engine.

The cylinder *b* is attached to the walking-beam *a*, which oscillates on a rock-shaft, and whose other arm is connected by a pitman with the fly-wheel crank. The piston is at the upper end of a hollow rod *f*, which also oscillates on a hollow rock-shaft *g* divided into two compartments. The piston is hollow, forming a steam-chamber, within which is a slide-valve *i*; it has also

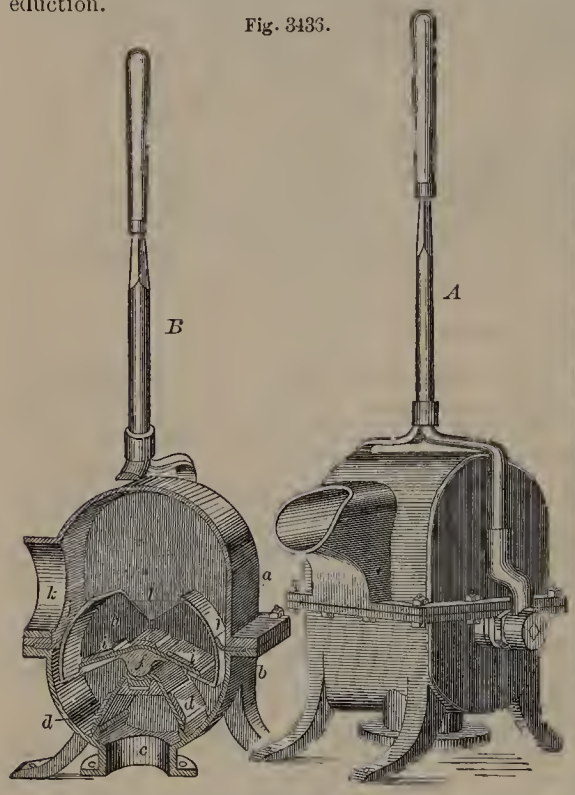
Fig. 3435.



Oscillating-Piston Engine

suitable inlet passages and an exhaust passage. Steam is admitted through one of the induction-passages of the rock-shaft *g* and piston-rod *f*, alternately above and below the piston by means of the slide-valve *i*, operated by a rod extending through the induction-passage of the piston-rod and reciprocated by a small rock-shaft connected with the crank-shaft; this causes the reciprocation of the cylinder, while the piston oscillates upon the rock-shaft *g*. The other passages of the piston-rod and rock-shaft serve for eduction.

Fig. 3436.



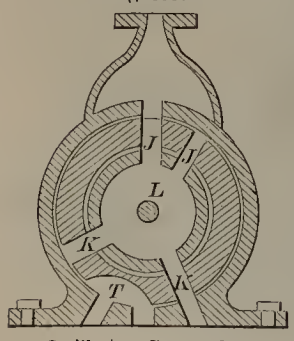
Oscillating Pump.

Os'cil-lat-ing Pump. The pump, Fig. 3436, is made in two sections *a b*, flanged and bolted together. The induction-chamber *c* has upwardly opening valves, through which water is drawn by oscillating the handles *A B*, causing corresponding oscillation of the shell *j j*, which turns upon *f* as a center, and is divided by radial plates provided with upwardly opening valves *d i* into chambers into which the water is successively admitted at each oscillation and discharged through the eduction-opening *k*.

Os'cil-lat-ing Pump-spear. (*Nautical.*) A revolving arrangement like a winch, for working a pump-rod.

Os'cil-lat-ing Valve. 1. (*Steam.*) A valve which reciprocates on a pivot, as the disk and trunnion valves of oscillating-cylinder steam-engines.

Fig. 3437.

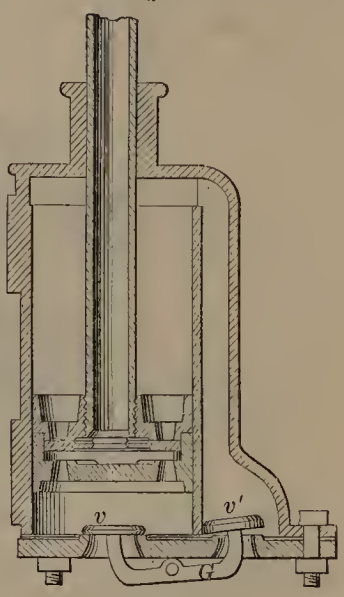


Oscillating Steam-Valve.

In Fig. 3437 steam is admitted to the center *L* of the hollow valve, through passages *J J*, communicating with the steam-chest; *K K* are induction-openings to the steam-cylinder; *T*, eduction-port.

Oscillating steam-engines frequently have oscillating valves working in their trunnions. Others are oscillated by bar or crank connection to a fixed object while the cylinder vibrates.

Fig. 3438.



Oscillating Pump-Valve.

2. A pump-valve which reciprocates on a pivot. In the example, the valves *v* and *v'* are attached to a lever *G*, and batter upon their seats alternately.

O'si-er-peel'er. (*Agriculture.*) The process of peeling osiers by a cleft stick is shown at Kouna, Thebes. The uses of the osier among the ancient Egyptians were constant and various. Baskets were even more common then than now, as the products of the field, the net, and the hook were generally carried by men. The wheeled vehicles in Egypt were few and not capacious.

Machines for peeling osiers proceed in various ways. In Colby's, the osier wands are carried between vulcanized rubber rollers which press, rub, and wring the bark from the wood. A serrated metallic roller acts in connection with an elastic or yielding roller, both having an end chase or lateral reciprocation to rub off the bark of the wand. A rack or comb catches and removes the bark.

Easterbrook's has a pair of rollers, respectively convex and concave, which give a slipping pressure upon three sides of the wand and loosen the bark; a pair of wire brushes next come into play, and then rollers discharge it from the machine.

Other forms have rollers having various angular presentations to a disk against which they press the wand. Another has jaws to drag the willow past V-edges. Another rubs the willow between a wheel and a traveling belt.

Os'le-on-i'ron. (*Metallurgy.*) Bars specially made for the manufacture of wire.

Os'mi-um. Equivalent, 99.6; Symbol, *Os.*; specific gravity, 21.4; nearly infusible. A rare metal, sometimes found in a native alloy with iridium, and forming the hardest alloy known.

Os-mom'e-ter. An apparatus for exhibiting the force of osmotic action, by which liquids are impelled through a moist membrane, illustrating the phenomena of *endosmose* and *exosmose*. The device consists of a porous vessel or sac containing a saline solution and plunged in pure water.

The more rapid flow through the porous septum or wall is from the thinner fluid to the saline solution, and is termed *endosmose*. A slower current sets in the other direction, and is called *exosmose*. The result is a blending and ultimate uniformity of quality.

Os'mund Fur'nace. (*Metallurgy.*) A furnace formerly employed in Sweden and still employed to some extent in Finland for reducing bog-iron ore. This ore, consisting essentially of hydrated sesquioxide of iron, is extracted from the bottoms of lakes and rivers. It occurs in grains, cakes, or amorphous

masses, generally of a somewhat loose and friable texture, different varieties yielding from 25 to 50 per cent of pure iron.

The illustration is taken from a cut in Swedenborg's work on iron. *a* is a heap of the ore not calcined; *b*, a heap undergoing calcination on wood; *c*, calcined ore; *d*, borer employed in searching for ores; *e*, charcoal rake; *f*, iron shovel; *g*, tongs for withdrawing the bloom from the furnace; *h*, cinder hook, also used in taking out the bloom; *i*, bar for cleaning the cinder hole and tuyere hole; *j*, sledge used for hammering the bloom when taken out; *k*, lump of iron, *blästra*, or *osmund*, partly divided; *l*, hatchet; *m*, treadles for working the bellows; *n*, inclined plane for conveying ores to the top of the furnace; *o*, tap hole for cinders; *p*, tuyere; *q*, wood shovel for charging the furnace with ore. The female in the figure is engaged in spinning with the distaff and operating the treadles of the bellows at the same time. The furnace has a rectangular cavity at the bottom, into which the reduced iron was

Fig 3439.

Osmund-Furnace.

received, and which is provided with an opening near *q*, through which the bloom is extracted. During the operation of smelting this is built up temporarily with stones. The inner lining is of refractory stone, and between this and the outer wooden casing is a filling of earth. The iron produced may be forged, but is usually of a mixed character, requiring to be remelted to render it malleable.

A furnace of this kind yielded about 1½ tons of iron weekly, of which from 33 to 50 per cent was lost in working it up into an *osmund* or bloom. In Finland, as has been observed, this primitive contrivance still maintains its ground beside the high-blast furnace, seeming to be well adapted for producing a good quality of iron from the peculiar ore employed. It formerly afforded lucrative employment to the Swedish peasant during the winter season. When the farm labors of the year were over, he went into the woods for some weeks with his wife and family, with whose aid he extracted the iron, which was sold for a small amount of ready money at some market town.

Os'na-burg. (*Fabric.*) A kind of coarse linen, made of flax and tow, originally imported from Osnaburg, Germany.

Os-te'o-tome. (*Surgical.*) An instrument to cut a bone; specifically, one to cut the bones of the fetal cranium when it is necessary to much reduce it to facilitate delivery.

Ot-a-cous'tic. (*Surgical.*) An instrument to improve the sense of hearing.

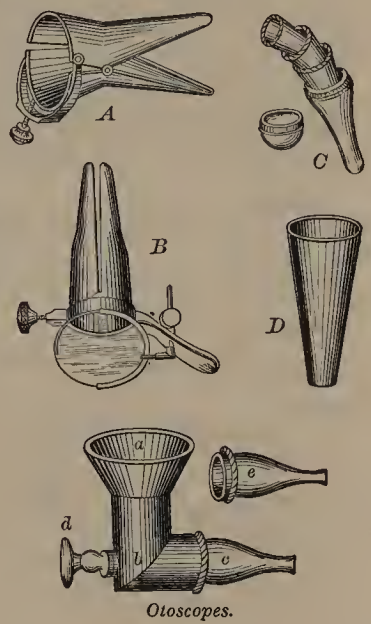
O'tho-scope. (*Surgical.*) An instrument invented in 1851 by Czermak, for holding water round the eye to enable the interior to be seen. It has the effect of preventing the cornea acting as a convex refracting surface. It is a little reservoir of glass, having three sides, and when placed against the cheek and nose and filled from above with water, the eye can be kept open in it under the water. It is superseded by Helmholz's OPHTHALMOSCOPE (which see).

O'to-phone. An ear-trumpet.

O'to-scope. (*Surgical.*) *a.* An instrument for viewing the interior of the ear. *Otoscopium.*

To this class belong the different patterns of car-speculums (*C D*), funnel-shaped, of high polish inside, through which light is reflected by means of a concave mirror; and the bivalve speculum *A*, which admits of expansion of the meatus auditorius, etc.

Fig. 3440.



Simrock's otoscope (*B*) is a funnel-shaped bivalvular instrument with magnifying-glass.

Clark's reflecting otoscope (lower figure) consists of an angular tube, one extremity of which is expanded to receive the rays of light from the window, a gas-jet, or lamp, while the other is prepared for the adaptation of specula of various sizes.

Otoscopes.

The light enters at the flaring extremity, and is reflected from the surface of a polished steel mirror, which is placed transversely across the angle *b*, and is thrown upon the tympanum through the speculum *c*. A small tube proceeds from the eye-piece *d*, and, transfixing the mirror, extends just into the speculum *c*. At the extremity of this tube, a carefully ground lens is introduced, which greatly magnifies the objects which are seen through the speculum. The smaller speculum *e* can be adjusted in place of the one upon the instrument when required.

b. An instrument enabling the examiner to detect the sound of air passing through the tympanitic cavity in certain morbid conditions. An *ear-explorer.*

The *otoscope* of Toynbee is an elastic tube with ivory extremities, one to fit the operator's, the other the patient's, ear. Air being blown into the eustachean canal, you determine with it whether the tympanum be sound or perforated.

Ouch. Formerly *ouche;* see King James's translation of the Bible, Exodus xxviii. 11:—

"Engrave the two stones [onyx] with the names of the children of Israel; thou shalt make them to be set in *ouches* of gold."

Also in Exodus xxxix. 18:—

"And the two ends of the two wreathen chains they fastened in the two *ouches* and put them on the shoulders of the ephod, upon the forefront of it."—BISHOP'S "Bible," 1568.

The collet of a jewel.

The part of a setting which grasps the stone. The *bezel*.

An ornamental collar of gold.

From the word *ouche* comes *brooch*, the modern name of the ornamental dress-clasp. This was formerly a clasp or button, and by the addition of a *broach*—a pin—(Fr. *broche*), received its present form.

Out'burst-bank. (*Hydraulic Engineering.*) The middle portion, as to elevation, of a sea embankment. The lower portion is the footing, and has a base of 5 to a hight of 1. The *outburst* has a base of 2 to 1 of hight, and is crowned with the *swash-bank*, which has the same proportions and a level on top of 4 to 5 feet under ordinary circumstances, where it is not to be used as a road.

Out'crop. (*Mining Engineering.*) The emergence of a stratum or seam at the surface. *Basset.*

Out'er Form. (*Printing.*) The form commencing with the first page of the sheet. It is usually worked off last.

Out'fall. (*Hydraulic Engineering.*) The point of discharge for, or the embouchure of a drain, culvert, or sewer.

Out'haul. (*Nautical.*) A rope used to extend the clew of a boom-sail.

Out'keep-er. (*Surveying.*) A small dial-plate having an index turned by a milled head underneath, used with the surveyor's compass to keep tally in chaining.

The dial is figured from 0 to 16, the index being moved one notch for every chain run.

Out'rig-ger. 1. (*Nautical.*) *a.* A spar for extending a sail or rope beyond the points of attachment furnished by the hull.

b. A boom rigged out from a vessel to secure boats to when the vessel is at anchor.

c. A floating timber attached by spars to the hull and floating parallel therewith. Used with crank or narrow boats to support them upright in the water under a press of canvas which would otherwise upset them. Principally used with the *proas* of the Malays and Ladrones. The lesser or leeward boat of the double canoe of the Pacific-Islanders is called a *hamma*.

d. A spar projecting over the stern of a boat for assistance in hauling out the *clew*.

e. A light boat for matches.

2. (*Gearing.*) A wheel or pulley outside the frame to receive a belt or other driving connection.

3. Of a crane; the *jib*.

4. The cat-head.

5. (*Building.*) A beam projecting outwardly from a wall to support a hoisting tackle.

Out'side Car. (*Vehicle.*) An Irish jaunting-car in which the passengers in two rows sit back to back, with their feet on boards outside of the wheels. The *inside* variety is shown under CAR.

Out-sid'er. (*Locksmithing.*) A pair of nippers with semi-tubular jaws, adapted to enter a keyhole and grasp the pin of a key, so as to turn it and unlock the door from the outside.

Out'side Bel'ly-band. (*Harness.*) An extra belly-band used on single harness, to prevent the thills rising too high.

Out'works. (*Fortification.*) Works included in the defense of a place, but outside the *parapet*. *Detached* works are beyond the *glacis*.

Ou-vreaux'. (*Glass.*) The *peep-holes* of a plate-glass furnace.

O'val Chuck. A chuck invented by Sharp, for oval or elliptic turning. See CHUCK.

O'val Com'pass. A compass for describing ovals. See ELLIPSOGRAPH.

O'val File. A file whose cross-section is elliptical or oval. Used sometimes as a *gulleting* file. Called by the French *limes à double dos*.

Ov'en. A chamber in which objects are baked by artificial heat.

The division may be made into these kinds:—

1. *Domestic.*
2. *Baker's.*
3. *Metallurgic.*
4. *Glass-annealing.*
5. *For clay and ceramic ware.*

The oven of the Society-Islanders is a pit in the ground paved with large stones, over which a fire is lighted. When the stones are hot enough, the embers are removed, the stones covered with green cocoa-nut leaves, the dressed pig wrapped in plantain-leaves, placed in the hole, and covered with hot embers, on which are placed bread-fruit and yams wrapped in plantain-leaves. Captain Cook said it was the best mode of cooking he ever saw. It is a pity that he was afterward subjected to it. He was sent by the English government to the South Seas to observe a transit of Venus, and was killed and eaten by the natives of Owhyhee, February 14, 1779.

The early Egyptian oven was a crock sunk in the ground and heated by a fire built inside. To the sides of the crock wet lumps of dough were attached and baked by the heat. It explains how the frogs with which Egypt was plagued came into the *ovens*. The cannibals of the Feejee Islands make a hole in the ground, and place therein the meat (*bakolo*, long pig, as they called a human carcass) and heated stones, covering all with leaves. The Rocky Mountain Indians collect the grasshoppers in pits, and there cook them with heated stones. These are primitive ovens, and with certain variations may be found among most barbarous nations and among some who have retained primitive customs.

1. The domestic ovens are of three kinds:—

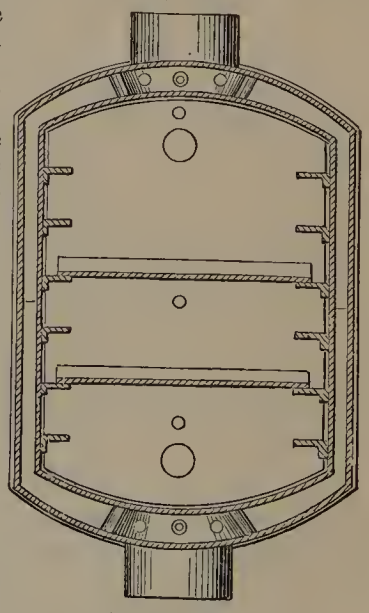
a. Stove ovens.

b. Dutch ovens, so called.

c. Out-ovens, heated by fuel. These resemble the baker's ovens.

a. Stove ovens are usually a part of the stove, and vary in their position with the shape and capacity of the stove. Several forms are shown under COOKING-STOVE, p. 615.

Fig. 3441.



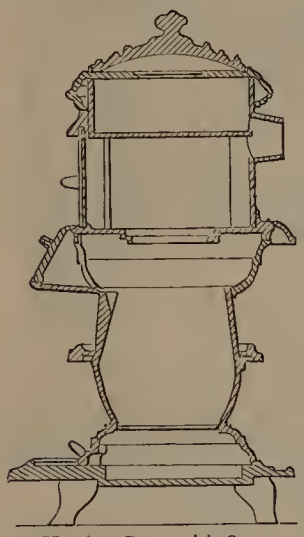
Elevated Oven.

The oven of the range is alongside the fire-chamber, as in Fig. 1435, p. 614. See also RANGE.

The *elevated oven* is a chamber surrounded by a spreading or enlargement of the flue, as in Fig. 3441. See also Fig. 1439, p. 615.

Another form is an oven combined with a heating stove, some varieties of which are known as "parlor cooks." Fig. 3442 is an instance, in which the cast-iron fire-chamber is surmounted by a cap, and the latter by a cylindrical casing containing an oven encompassed by the caloric current. It combines in small compass heating and cooking arrangements.

Fig. 3442.



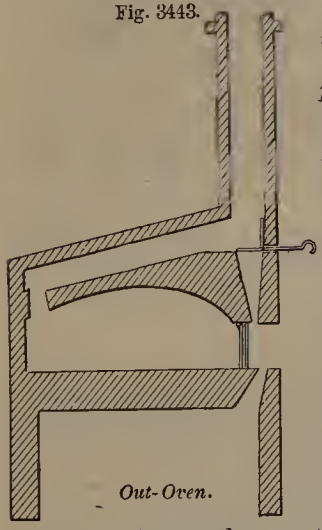
Heating Stove with Oven.

b. The *Dutch oven*, so called, is of two kinds. One is a *skillet* or *baking-pot*, used in cooking by wood coals on the hearth, the iron pot being set upon a bed of hot coals and others piled on to its lid.

The other form is a sheet-metal affair placed in front of a fire in a grate, so as to cook by radiation from the open fire, the closed back of the chamber keeping in the heat. See Fig. 1809, p. 765.

c. The *out-oven*, as it is called, was commoner aforetime than now. It is so called because built out of doors; not a *house*-oven. It has a domed chamber, is built of brick, and is heated by means of light wood or sticks burned inside. The bricks having been well heated by the fire inside, the ashes and embers are raked out, the floor swept, and the batch of dough loaves introduced by a *peel*, which is a flat wooden shovel with a long handle. The door is then closed. The result is very satisfactory when good material meets with good management. The illustration shows a form with a front, back flues, damper, a rake-hole for the embers, and an ash-pit beneath.

Fig. 3443.



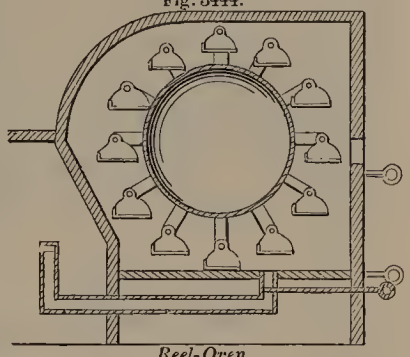
Out-Oven.

Loaves found in a Pompeian bakery indicate that the name of the meal, wheat, rye, beans, etc., was stamped on bread. Among the recent discoveries in a baker's oven, so hermetically sealed, says Marc Monnier, that not a particle of volcanic ashes had entered, there were eighty-one loaves, whole, hard, and black, found just as they had been placed on the 23d of November, A. D. 79. Enchanted with the discovery, Fiorelli himself climbed into the oven and took out the precious relics with his own hands. Most of them weigh about a pound, are round, depressed in the center, and divided into eight lobes. Loaves precisely like them are still made in Sicily.

2. The *baker's oven*. *a.* Until lately, and even now in many places, this was but an extension of the one last described; the additional capacity enabling it to act upon a larger quantity, and the larger size requiring greater skill in the building and the mode of conducting and using the heat economically. Some ovens of this kind are heated by steam.

b. The *reel-oven*. This has a series of pans or trays suspended from the periphery of a skeleton cylinder, or, as it were, from the spokes of two wheels keyed on to the same shaft. The pans are preserved in a horizontal position by means of suspending each from a point above its center of gravity (Ball, September 23, 1856; McKenzie, May 1, 1860; Coburn, January 30, 1872); by a suspended weight beneath the pan (Ball, July 19, 1870); by radius rods like those of a feathering paddle-wheel (McKenzie, June 6, 1871).

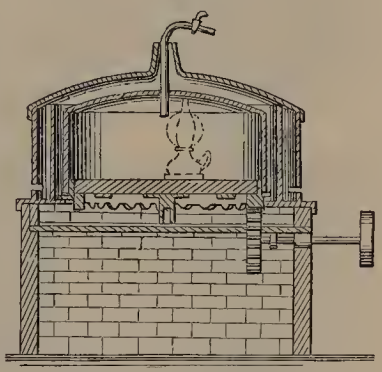
Fig. 3444.



Reel-Oven.

The reel-oven is shown in Fig. 3444. The rate of revolution is such that a loaf is baked during one revolution. As a pan comes opposite the mouth of the oven, the baked loaf is taken off and a loaf of dough placed upon it. The pans are hung to radial arms projecting from a rotating drum which reflects heat upon the top of the matters contained in the pans. Flues within the oven have dampers by which the escape of heat to the chimney may be permitted. The work is thus continuous, the door being closed in the intervals of taking off the bread and putting on the dough as the pans arrive in succession opposite to the doorway. The reel is turned by a wheel on the axis which extends outside the wall of the oven.

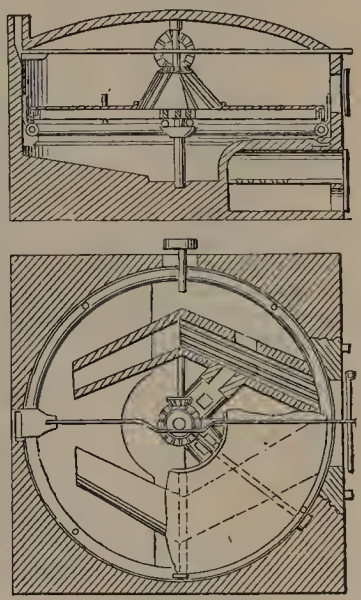
Fig. 3445.



Rotary-Hearth Bake-Oven.

c. The *traveling-apron* oven is another form of continuously working oven. In Crumbie's oven, April 9, 1872, shelves are suspended from a series of traveling axles, which are connected by an endless chain of bars and caused to travel in an elliptical path, presenting the shelves consecutively at the oven door, as described just above. An endless-apron oven was patented by Doncale in 1806.

Fig. 3446.



Rotary Oven.

d. An *endless chain* with suspended trays, traveling in a tall vertical flue, is shown in Jennison's patent, February 1, 1859.

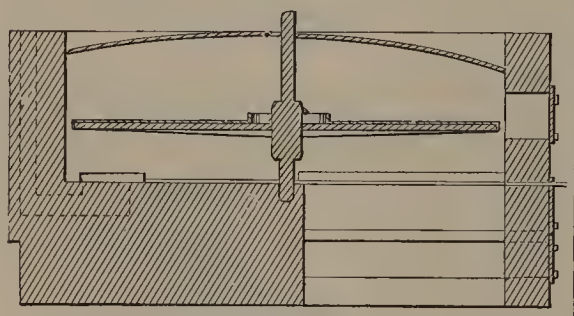
e. The *rotary hearth* is a circular floor having a cogged rim or a stem with a gear-wheel upon it.

Fig. 3445 is an illustration of the former, and Fig. 3446 of the latter. In each case, the floor for the bread is in a dome-roofed chamber, heated from the furnace beneath. The oven usually forms a part of the flue, the heated gases from the fire passing into and through the oven. The lower part of Fig. 3446 shows the duplicate arrangement of fireplace and the distribution of the heat.

3. *Metallurgic ovens.* These are of two kinds.

a. Roasting ovens, which may be properly termed *furnaces*, as in the example, where pyrites or arsenical ores are exposed to a calcining heat by which

Fig. 3447.



Metallurgic Roasting-Oven.

they are rendered friable, the metallic portion being oxidized and converted in a calx. See also ORE-CALCINING FURNACE; ROASTING-FURNACE.

b. The *annealing oven*, in which iron articles are brought to a heat below fusion-point and then allowed to cool gradually, so as to decarbonize them and remove the brittleness of their ordinary "cast-iron" condition. See MALLEABLE-IRON FURNACE; ANNEALING-FURNACE, Fig. 251, p. 114. See also ANNEALING, pp. 110–114.

Other heating-chambers may be termed *ovens;* such as the *assay-furnace*, Fig. 395; the *muffle-furnace;* the *vulcanizing-furnace*, etc.

4. The *glass-annealing oven* is a chamber in which blown, pressed, or rolled glass is placed to allow it to cool slowly, in order that the particles may arrange themselves in a static condition, not liable to fracture and fly to pieces upon slight provocation. See ANNEALING, p. 110; LEER.

5. *Porcelain oven.* The firing-kiln of the porcelain manufacture. The ovens are conoidal structures of brick, 22 feet in diameter and 18 to 21 feet high, and are clustered around a brick building of similar structure, but larger, called a *hovel.*

The *ovens* are heated by fireplaces or *mouths*, about 9 in number, built around them. Flues in connection with these converge under the bottom of the oven to a central opening, drawing the flames to this point, where they enter the oven; other flues, termed *bags*, pass up the internal sides to the hight of about 4 feet, conveying the flames to the upper part. See PORCELAIN; POTTERY.

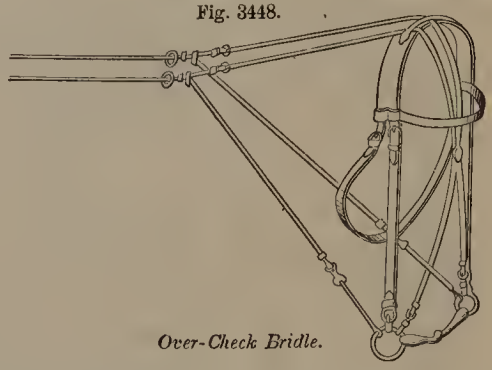
O-ver-cast'ing. 1. (*Bookbinding.*) The doubling of an edge of a single leaf or plate to be sewed in, so as to give a hold to the thread.

2. (*Sewing.*) Laying two edges of cloth together and whipping them by a thread which goes over and over. Used to prevent raveling of the edges of two fabrics sewed together.

O'ver-check. See OVER-CHECK BRIDLE.

O'ver-check Bri'dle. (*Harness.*) A driving-bridle having a rein passing over the head of the horse, so as to draw the bit upward into the angle

Fig. 3448.

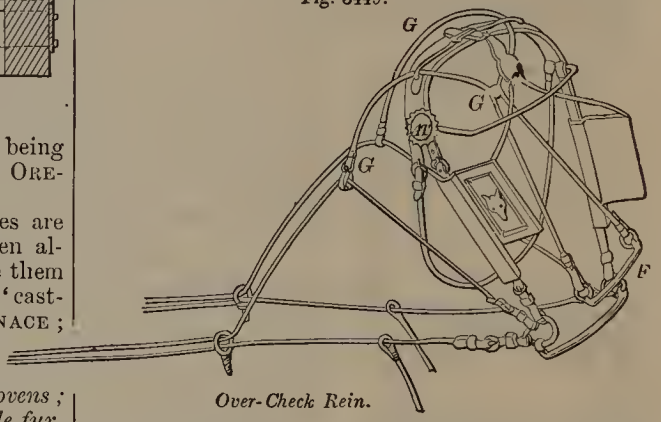


Over-Check Bridle.

of the horse's mouth. In the example, branch reins are attached to each end of the driving-reins, one branch answering for a gag-rein, passing over the horse's head to the ring of the snaffle-bit; the other branch connects to the same ring of the bit. The devices correspond on each side.

O'ver-check Rein. (*Harness.*) A rein passing over the head of the horse to the bit, so as to pull upward upon the bit when drawn upon. The

Fig. 3449.

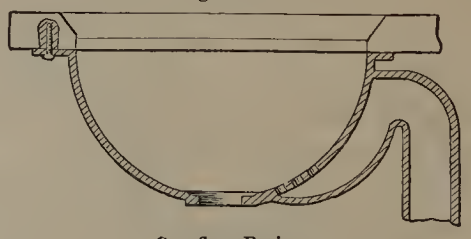


Over-Check Rein.

example shows one which has an additional or safety rein which leads through the runners to the rings of the usual bit, and also draws upon the *over-check* rein *G*; this is connected to a separate bit *F*, which is thereby pulled upward against the palate.

O'ver-flow-ba'sin. One having a pipe to convey away excess of water and prevent it running over the brim. In the example, the overflow holes are near the bottom, but communicate with an up-

Fig. 3450.



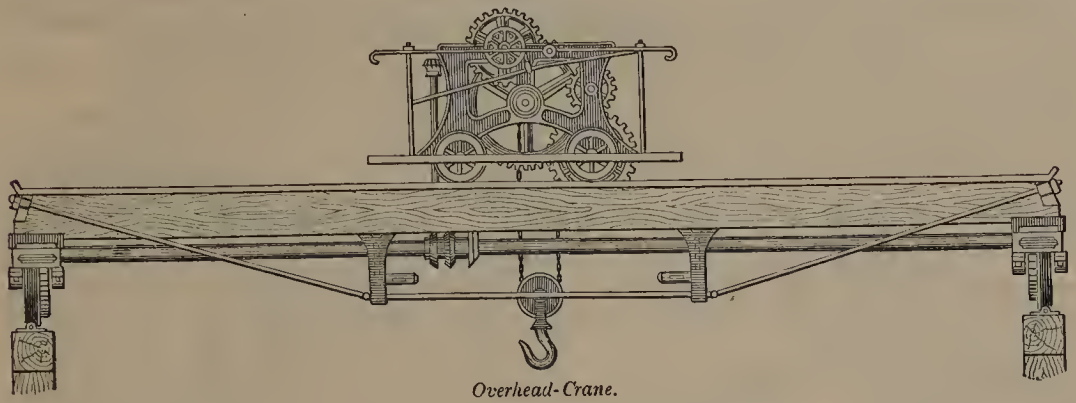
Overflow-Basin.

wardly bent pipe to allow the basin to hold water up to a given level.

O-ver-haul'. (*Nautical.*) To extend the blocks of a tackle from each other and slacken the fall, that it may render through the blocks. To *fleet.*

O-ver-head'-crane. One which travels on elevated beams in a foundry, machine-shop, or on high scaffolding above a structure. The crab travels on wheels, and the object is suspended from chain-tackle beneath. See also STEAM-CRANE.

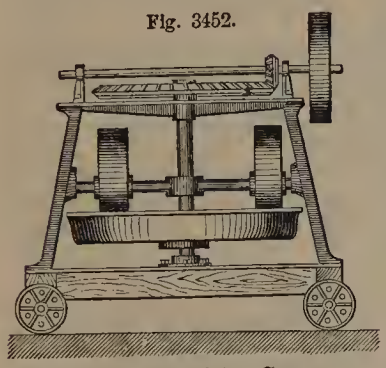
Fig. 3451.



Overhead-Crane.

O-ver-head′-gear. Driving-gear above the object driven, as in the mortar-mill, Fig. 3452, in which the bevel gearing driving the rolls of the Chilian mill are placed overhead, in contradistinction to such as receive the impulse from below, as in Figs. 146 and 147.

Fig. 3452.



Overhead Driving-Gear.

O-ver-head′-mo′-tion. (*Turning.*) A frame attached to the bench of a lathe, and rising to a hight about a foot above the head of the workman. It supports a spindle on which is a pulley driven by a band from the fly-wheel; another pulley on the same spindle carrying a band which passes down to the pulley on the spindle of the eccentric cutter. The latter spindle, to whose end the work is chucked, is stationary, while the cutter is revolved.

O-ver-head′-rein. One which passes over the horse's head, between the ears, and down the front of the face to the bit, so as to pull the latter up into the angle of the mouth, instead of pulling squarely against the jaw. See OVER-CHECK REIN.

O-ver-head′ Steam-en′gine. An engine in which the cylinder is above the crank, the thrust motion being downward. Not an uncommon form with trunk and oscillating engines.

O-ver-heat′ing-pipe. (*Steam-engine.*) A pipe through which steam is caused to pass in order to be superheated.

O-ver-lap′-joint. One in which the parts lap upon each other, in contradistinction to a butting-joint, in which the edges merely are in contact. See ANGLE-JOINT, for a number of illustrations in which overlapping portions are joined by solder or by bending over upon each other.

O′ver-lay. (*Printing.*) A piece of paper pasted upon the tympan-sheet at a spot where the impression is desired to be dark and effective. This is used to bring out the darker parts of the engraving, while the lighter portions are partially relieved of pressure by *cutting out* the tympan-sheet over such places.

It is also used to obtain a proper impression of the low part of a form.

O-ver-reach′ing de-vice′. (*Menage.*) An attachment to the leg or foot of a horse to prevent the catching of the toe of the hind foot upon the heel of the fore foot in rapid traveling. See LEG AND FOOT GUARDS FOR HORSES.

O-ver-sail′ing. (*Architecture.*) Projecting beyond the general face.

O-ver-seam′ing. (*Sewing.*) Another name for overcasting, in which the edges of two pieces of cloth are laid together and whipped over and over, to prevent raveling.

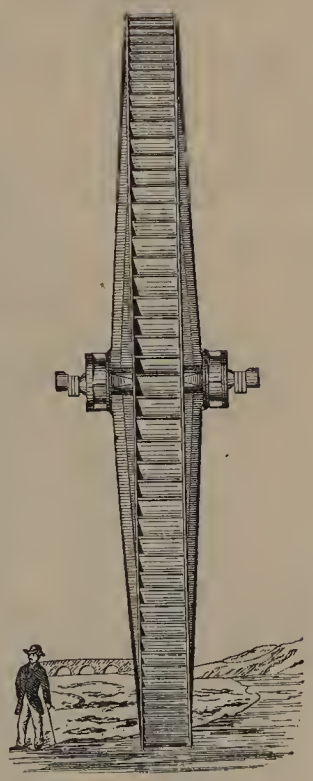
O′ver-shave. (*Coopering.*) A jointer having a concave-edged bit, on which the backs of staves are dressed.

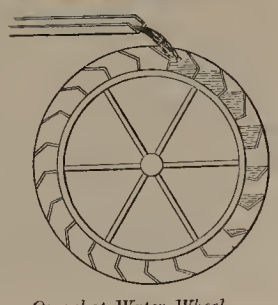
O′ver-shoe. 1. An india-rubber shoe to protect the usual foot-covering while walking in muddy streets. A *goloshe.*

2. A shoe of buffalo hide, hair inward, used in sleighing or winter traveling.

O′ver-shot-wheel. A form of water-wheel in which the water flows upon or near the top of the wheel, as in Fig. 3453. It acts principally by gravity, though some effect is of course due to the velocity with which the water arrives. Some overshot-wheels have a circular rack or cogged rim near the periphery, so as to bring the body of water in close proximity to a pinion which communicates the motion to the machinery. In such cases, the frame of the wheel is a skeleton, comparatively light. In ordinary cases, the wheel is united by the usual arms or spokes to an axis which forms the main driving-shaft.

Fig. 3453.





Overshot Water-Wheel.

The upper figure shows a large wheel of the latter description.

O′vo-lo. A molding whose profile is a quarter of a circle; or, in the Grecian, a portion of a cycloid.

A quarter-round. See MOLDING.

O'vo-lo-plane. (*Joinery.*) A joiner's plane for working ovolo moldings on sash, or elsewhere. Ovolo *routers* are made like spokeshaves, to work in circular sash-frames.

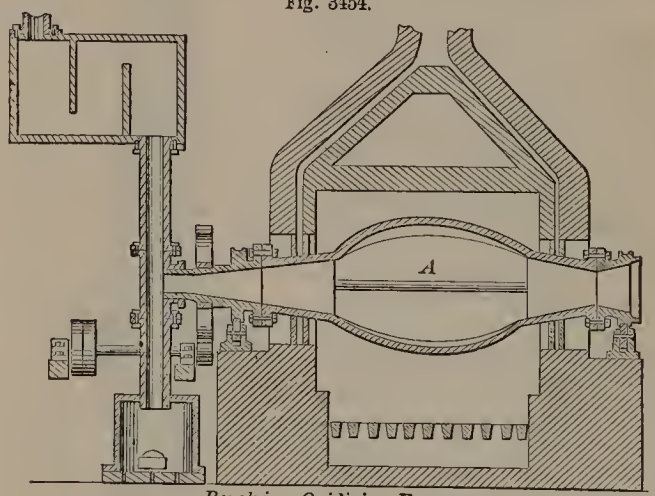
Ox-bow. (*Husbandry.*) The bent piece of wood which passes under the neck of the ox, the upper ends passing through the yoke. See OX-YOKE; YOKE.

Ox-brake. The ox-brake resembles that used for shoeing refractory horses, and consists of a stall where the neck is confined, straps to hold the animal suspended if he prove sullen and attempt to lie down, and posts and bars to which the feet are lashed for shoeing. See *a*, Fig. 3456.

Ox-eye. (*Building.*) An oval *dormer*-window.

Ox'i-diz-ing-fur'nace. (*Metallurgy.*) A furnace for treating ores or metallic substances, in which the material is exposed to an excess of air, the oxygen of which unites with the metal, forming an oxide. With ores, it may be said to be roasting with an excess of air. The term is somewhat general, and to speak of *oxidizing*-furnaces is a mode of stating chemically the action of certain furnaces under given conditions of access of air. The same furnace might be a *reducing*-furnace were the air more nearly shut off. A *reducing* flame is one which has an excess of gases, and abounding in carbon, the effect of which is to take up the oxygen from the material, *reducing* it. A neutral furnace

Fig. 3454.



Revolving Oxidizing-Furnace.

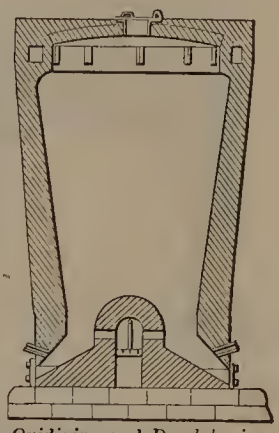
is one in which there is enough of air admitted for perfect combustion of the fuel, and no more; the effect is therefore *nil* as regards the question of *reducing* the oxide, or *oxidizing* the metal.

An illustration, from among many, may be drawn from the process of *puddling* iron. The flame is first an *oxidizing* flame with an excess of air, the oxygen uniting with the carbon of the metal to convert it into relatively pure iron; a *reducing* flame is then allowed for a while, the fuel being in excess, and carbonaceous gases going over to reduce the oxide; after this air in moderate degree is admitted, the fire burning clear and consuming the fuel perfectly, as near as may be, the flame being *neutral* and merely heating the iron.

In Fig. 3454 is shown an oxidizing furnace, in which the ores are rolled over and over to expose them more fully to the action of the air. The revolving chamber has hollow trunnions open at one end to the air, and at the other communicating with the chimney. The material in chamber *A* is heated by fire in the furnace beneath, and particles carried over are caught in the upper or lower chamber, according to their relative gravity.

Fig. 3455 is a form of oxidizing and desulphurizing furnace for the treatment of auriferous pyrites and other similar ores with the gases formed by decomposing steam or superheated steam. The coal is placed in an ordinary fire-box, with grate-bars, so as to allow a good draft of air to support combustion. Steam from a boiler, which may be heated by the waste gases of the furnace, is brought into the incandescent coal in the fire-box. The resulting gases are passed into the chamber containing the ore to be treated. For the purpose of regulating the temperature of the gases in the ore-chamber, and to assist in oxidizing the metals, an additional supply of steam is passed into the ore-chamber without being passed through the fire-box.

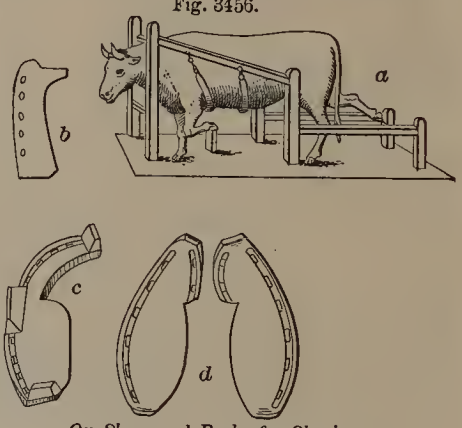
Fig. 3455.



Oxidizing and Desulphurizing Furnace.

Ox-shoe. Among the Orientals oxen to be shod are thrown, and their four feet drawn up into a

Fig. 3456.



Ox-Shoes and Brake for Shoeing.

bunch by cords. The animal being then helpless, the operation is completed at leisure.

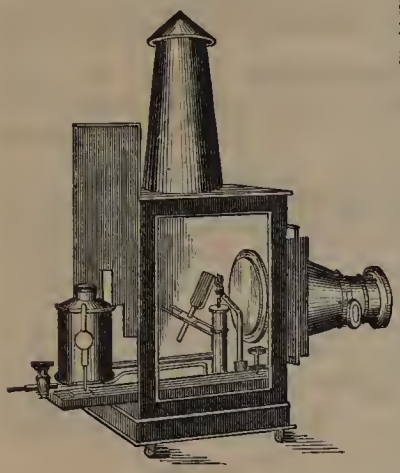
An ox-shoe consists of a flat piece of iron with five or six holes near its outer margin to receive as many flat-headed nails, whereby it is secured to the hoof. The shoe *b* represented has a projecting flap, which is bent into the cleft of the foot and flattened up against the inside of the hoof, to assist in keeping the shoe in place. This projection is not always employed. *c d* are also forms of ox-shoes.

Ox-y-cal'ci-um-light. One produced by a jet of oxygen gas forced through the flame of an alcohol lamp on to a piece of lime. This light will exhibit the usual paintings on a screen 10 or 15 feet in diameter with very brilliant effect. It is not so brilliant as the oxyhydrogen light, but it is much safer to manage. The apparatus is less bulky, troublesome, and expensive. The light is equal in brilliancy to ten argand-lamps of ordinary dimensions.

See also CALCIUM-LIGHT; DRUMMOND-LIGHT; OXYHYDROGEN LIGHT.

Ox-y-ge-na'tor. A contrivance for throwing a stream of oxygen into the flame of a lamp.

Fig. 3457.



Oxycalcium-Light.

Ox'y-gen-gas Ap'pa-ra'tus. Oxygen gas was first discovered by Dr. Priestly August 1, 1774. Scheele and Lavoisier appear to have made the discovery independently very shortly afterward.

Dr. Priestly first obtained the gas by heating red precipitate (red oxide of mercury, HgO) to a temperature of 752° Fah., by which the oxygen is expelled from this compound. Lavoisier verified the result by boiling mercury in a given quantity of air, thus forming red precipitate. Scheele obtained oxygen while engaged in experimenting upon some of the ores of manganese.

It may be readily obtained by heating chlorate of potash, mixed with ⅓ or ¼ its weight of black oxide of manganese, in a glass vessel to a temperature of 450° or 500° Fah., and collecting over a water-bath. This process is, however, rather expensive.

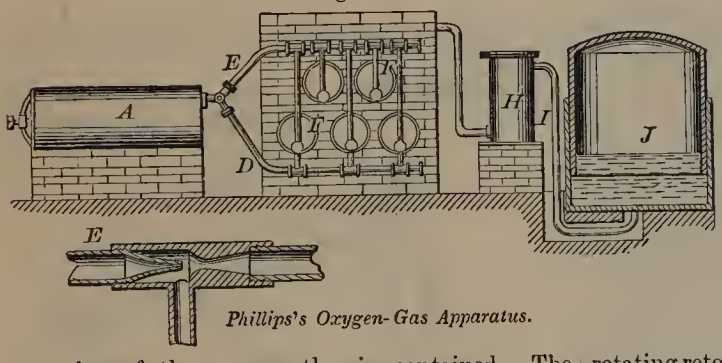
At the London Polytechnic Institute, where large quantities are used for the oxyhydrogen light, it is procured by heating black oxide of manganese (MnO_2) in wrought-iron bottles; two equivalents of the gas are liberated from each three molecules of the oxide, leaving Mn_3O_4, or red oxide of manganese.

A pipe is attached to the upper part of each bottle, through which the gas, after being purified by passing through a simple washing apparatus, is delivered into a copper gasometer. The pure oxide should yield ⅛ its weight of the gas, but in practice rarely more than half that amount is obtained.

Fig. 3458 illustrates an apparatus for obtaining oxygen gas from permanganates by means of steam.

A is the boiler from which a current of steam is forced by the pipe *D* into the retorts *F*, extracting

Fig. 3458.



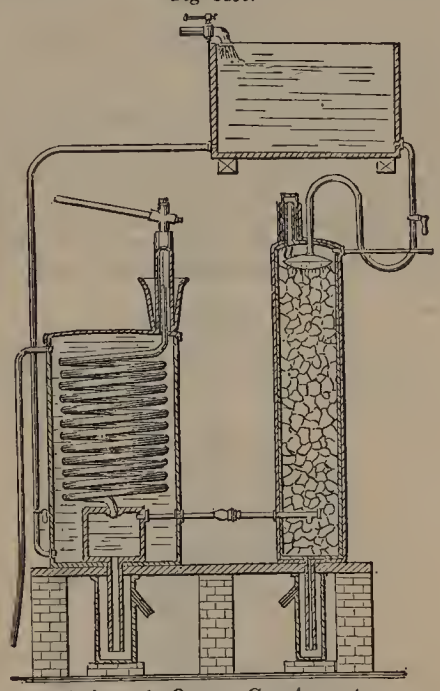
Phillips's Oxygen-Gas Apparatus.

a portion of the oxygen therein contained. The steam current then passes, carrying the oxygen with it into the condenser *H*, where the steam is condensed, the oxygen being conveyed through the pipe *I* into the reservoir *J*.

To assist the process, a partial vacuum is formed in the retorts by a pipe *E* on the Giffard injector principle. When all the oxygen capable of being extracted is liberated, the steam is shut off and a fresh portion of air admitted through an appropriate pipe; part of its oxygen combines with the exhausted manganate, forming a permanganate which is treated as before.

Archereau's apparatus comprises a cupola of fire clay, inclosed in a leaden shell within which sulphuric acid is decomposed by exposure to an extended heating surface formed by iron bars. The mingled sulphurous-acid gas and oxygen are passed

Fig 3459.



Archereau's Oxygen-Gas Apparatus.

through a washer, where part of the acid is absorbed, the remainder being condensed by passing through a worm in a condenser.

In the process of Du Motay and Maréchal, oxygen is derived from the reactions between sulphuric acid and the oxides of various metals, which readily part with a proportion of this gas and reabsorb it from the atmosphere: the sulphurous-acid gas and oxygen liberated by this process are passed through a vessel containing oxide or carbonate of magnesia, which is converted into a sulphite; this is decomposed by heating, and the sulphurous acid which escapes is converted into sulphuric by treating with steam, air, or nitrous gas, the magnesian compound being again ready for use. The patent also embraces means for procuring oxygen by heating such compounds as permanganates, chromates, and ferrates, which are reoxidated at a lower temperature.

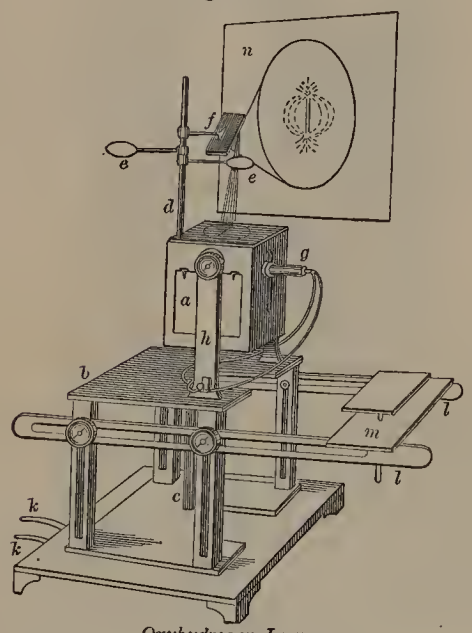
In Mallet's process, sub-chloride of copper is transformed by the air into an oxi-chloride, which parts with its oxygen when subjected to a red heat in rotating retorts lined with fire-clay. The oxi-chloride is mixed with 15 or 20 per cent of sand in the retorts. The oxygen passes through a washing-vessel to the gas-holder. Fresh oxygen is supplied to the contents of the retort by first cooling by jets of steam, and then forcing a current of air through it. For production of chlorine and oxygen at the same time, hydrochloric acid is injected in place of steam. According to the amount of acid injected oxi-chloride or pure chlorine may be evolved.

Ox-y-hy'dro-gen Blow'pipe. One used by mineralogists and chemists for reducing metallic ores in analyses. The flame is produced by the combustion of hydrogen gas in the presence of an atmosphere of oxygen, with which the combustible gas is mixed.

Ox-y-hy'dro-gen Lamp. One in which streams of oxygen and hydrogen in regulated quantities are commingled, the resulting flame being directed on a ball of quicklime and forming an extremely bright light; now used very largely by lecturers on science, to illustrate phenomena, and by exhibitors to project pictures upon a screen.

The body of the lantern *a* is swung between two uprights, to which it can be clamped firmly in any position required. The uprights are fastened in the top board of the stool *b*, which can be rotated in a horizontal plane round the upright tube *c*, to direct a beam of light in any direction. At one corner of the front plate is the bar *d*, carrying the lenses *e e* and the mirror *f*. These slide on the bar in the

Fig. 3460.



Oxyhydrogen Lamp.

same manner as the rings on a retort-stand, and can be turned out of use in a moment. The jet, the lower part of which is seen at *g*, slides through a collar working in the slit at the base of the lantern. The caoutchouc tubes from the jet pass through screw pinch tabs, one of which is seen on *h*, and then they pass through the tube and underneath the base-board, as seen at *k*. The cross-pieces *l l* serve to support a table *m*, on which apparatus, such as a prism, etc., can be supported. To show magnetic curves, cohesion figures, or anything which requires to be illuminated while in a horizontal position, the lantern is clamped in an upright position, shown in the figure. The glass plate with the magnet attached is laid over the condenser, and one or both lenses, according to the size of image wished, are brought into action. The mirror is then adjusted to throw the image on a vertical screen *n*. Should it be desired to direct a beam downward, as in showing the refraction of light, the lantern is clamped with the axial line of the lenses pointing obliquely downward. The mirror is either slipped off the bar or turned out of the way, the cross-pieces and tables being removed. For exhibiting ordinary lantern-slides or photographs, a clip is attached to the front of the lantern, the instrument clamped in a horizontal position, and the slides then exhibited in the usual manner.

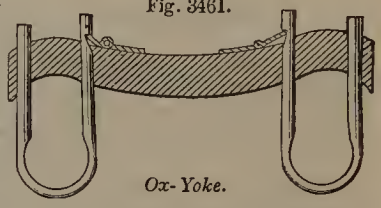
Ox-y-hy'dro-gen Light. A light of intense brilliancy produced by the combustion of lime in the flame of a combined jet of oxygen and hydrogen gases.

See CALCIUM-LIGHT; DRUMMOND-LIGHT.

Ox-y-hy'dro-gen Mi'cro-scope. A microscope in which the object is illuminated by the flame on a piece of lime or marble under the action of the compound blowpipe. The lime is placed in front of a concave mirror, and the object between this and a convex lens, by which its image, highly magnified, is thrown upon a screen so that it may be visible to any number of spectators at once.

Ox-yoke. The means whereby a steer is fastened to the tongue of the cart or wagon. It usually rests upon the neck, but the bar strapped to the forehead or poll goes by the same name. It is usually of the shape shown in Fig. 3461, and is held in place by bows.

Fig. 3461.

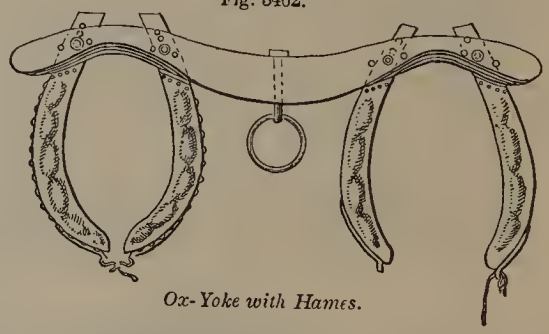


Ox-Yoke.

The bows are held in place by keys which pass through holes in the bows and rest upon the top of the yoke; or, as in the example, the hinged metallic plate engaging in a notch in the bow retains the same and obviates the use of a key.

Fig. 3462 shows a yoke with *hames* instead of bows. The hames are pivoted at their upper ends

Fig. 3462.



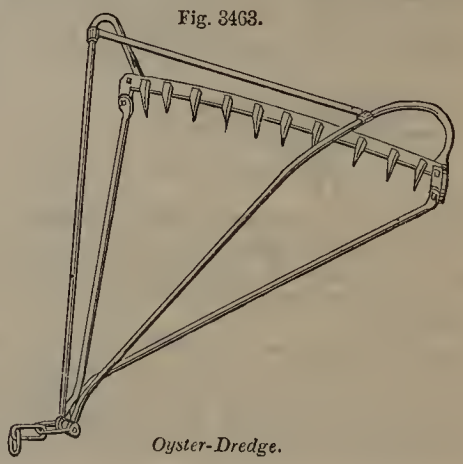
Ox-Yoke with Hames.

to the yoke, and fastened at the lower ends by straps.

See also YOKE.

Oys'ter-dredge. A rake and drag-net for gathering oysters from the beds. The dredge is

Fig. 3463.



Oyster-Dredge.

thrown overboard and dragged by a sail-boat over the oyster-beds. It is then hauled up by tackle and drawn on board over a roller on the gunwale of the boat.

A stout bag is fastened to trail behind the bow of the drag and catch the oysters upturned by the rake. See also DREDGE.

In olden times, the edible oyster was dived for, as the pearl-oysters now are.

"Oysters lie at the bottom of the sea, and one cannot get at them by any other means, except by diving to the bottom." — ATHENÆUS; EPIT., B. I. 22.

He also quotes Homer as saying, —

"An active man is he, and dives with ease"
(ILIAD, XVI. 745),

in reference to a man who gathered them fast enough to keep several persons supplied.

Epicharmus, in the "Marriage of Hebe," says: —

Bring "oysters with closed shells,
Which are very difficult to open, but very easy to eat."

The pearl-oyster of the Indian Ocean is mentioned by Theophrastus and Athenæus, who speak of it as a precious stone resembling a large fish's eye, and that expensive necklaces are made of them for the "Persians, Medes, and all Asiatics." Theophrastus says: —

"They are engendered in the flesh of the oyster, just as measles are in pork."

The oysters of Britain were highly esteemed by the epicures of the Roman Empire.

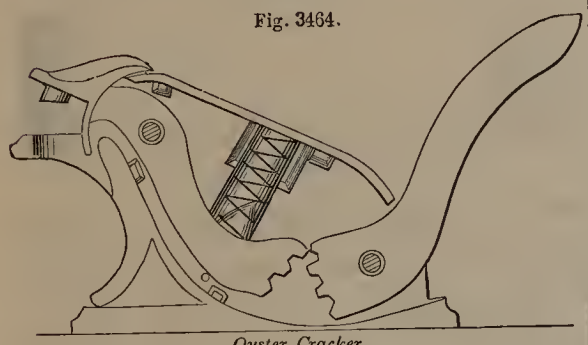
Oys'ter-knife. A strongly stocked and thick-bladed knife which is thrust between the shells of the bivalve, being a case of forcible entry. In America, the power of the mollusk is somewhat impaired by hammering upon the hinge, but in England the knife is driven between the shells without previously demoralizing the fortress.

Oys'ter-o'pen-er. An invention of Napier, England. The bivalve is laid on a stake and a notch taken out of the edge of the valves by a lever knife. It is then placed edgewise between a pair of knives, which are forced together and separate the shells.

Oys'ter-rake. One for raking up oysters from their beds. Usually dragged overboard by a sail-boat, and known as a *dredge*. See OYSTER-DREDGE.

Oys'ter-shell Crack'er. An implement for

Fig. 3464.



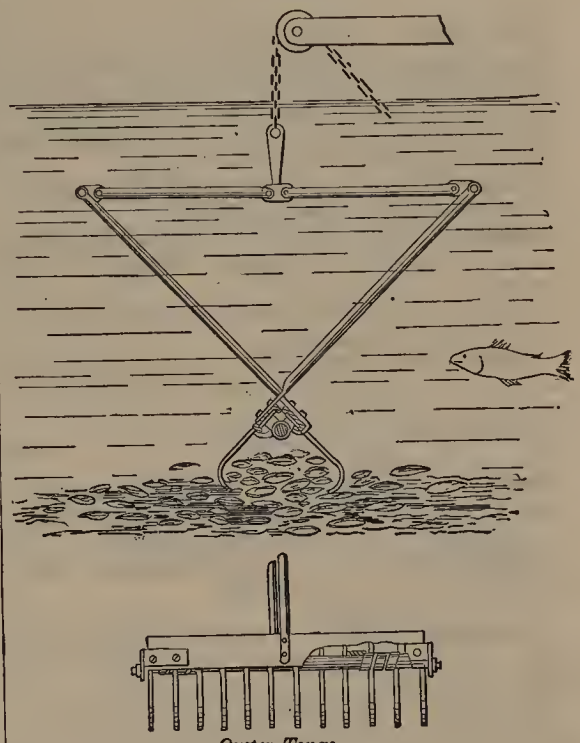
Oyster-Cracker.

breaking a notch in the shells of an oyster in order to facilitate entrance of the knife. The lower jaw is fixed and the upper one brought down by the lever and pivoted arm, which gear together.

Oys'ter-tongs. An instrument having two rake-shaped jaws and a pair of long handles, to grapple oysters in their beds and lift them to the surface.

On a large scale, as in Fig. 3465, the grappling-tongs are suspended over a beam rigged out from a boat, being held in extended position by a spring, and brought together by the action of raising, through

Fig. 3465.



Oyster-Tongs.

means of the toggle-rods. The head is sunk by a longitudinal bar to which the jaws are hinged.

O'zone-ap'pa-ra'tus. Ozone is an allotropic condition of oxygen, also called *active oxygen*. It has the property of decomposing iodide of potassium with liberation of iodine. Its odor led to its discovery by Schönbein in 1840, though the odor which oxygen acquires by the passage of the electric spark was noticed by Van Marum more than half a century previously. Van Marum also observed its power of attacking mercury. It perhaps may be considered as an instable and extremely active condition of oxygen, having a density 1½ times greater than ordinary oxygen.

Ozone may be obtained by placing a stick of freshly scraped phosphorus in a bottle filled with air and containing sufficient water to partially submerge the phosphorus; the vessel is then closed and kept at a heat of 60° to 70° Fah. for six or eight hours. It is also produced by passing the electric spark through oxygen gas in the electrolytic decomposition of water, and by the slow combustion of ether caused by plunging a heated glass rod into a vessel containing this substance.

According to O. Loew, ozone may be obtained by passing air through the flame of a Bunsen burner.

O-zo-nom'e-ter. An instrument invented by Moffatt, for ascertaining the amount of ozone in the atmosphere.

Paper or linen, imbued with a mixture of iodide of potassium and starch, is used.

A slip of paper so prepared is placed in a current of air and protected from rain, light, and foul effluvia for a period of from six to twenty-four hours. By exposure the paper becomes brown, and when wetted acquires shades of color varying from a pinkish-white and iron-gray to a blue. The paper is compared with a prepared chromatic scale.

P.

Pac; Pack. A moccasin having a sole turned up and sewed to the upper. Though now made of leather of various kinds, the *pac*, as used by the Indians of the Six Nations, for instance, was made of hide boiled in tallow and wax; or of *tawed* hide subsequently stuffed with tallow or wax.

Pach-om'e-ter. An instrument for measuring the thickness of the glass of mirrors.

Pack. 1. (*Coopering.*) The staves and headings of a cask hooped up in a compact bundle for transportation. A *shook*.

2. A pile or bundle of sheet-iron plates, for heating or rolling simultaneously.

Pack'ag-ing-ma-chine'. A machine for bundling yarns or goods into compact shape for transportation. A *bundling-press*.

Pack-cloth. Coarse baling material: hemp, jute, etc. *Gunny-cloth*.

Pack'et. (*Nautical.*) *a.* A mail or passenger vessel plying between port and port at regular times.

b. A vessel employed in carrying letters.

Pack'et-note. 1. A folded writing-paper, 9 × 11 inches, half the size of *packet-post*.

2. A size of note-paper.

Pack'fong. (*Alloy.*) A Chinese alloy known as white copper. Copper, 40.4; zinc, 25.4; nickel, 31.6. See ALLOY.

Pack'ing. 1. A contrivance or a material to close a joint. See PISTON; PISTON-PACKING.

In the atmospheric engines of Papin, Savary, and Newcomen, the piston was packed air-tight by means of flooding its upper surface with water. Watt obtained a patent for packing pistons with lubricators instead of water, 1769.

The piston-rod is also packed in its stuffing-box.

Various greasy materials with gaskets, oakum, etc., are used in joints which are screwed down; also collars of rubber, red-lead, luting. Flues and tubes are closed into the flue-sheets or tube-sheets by riveting. Tubes of condensers by thimbles, screw-joints, or preferably by Horatio Allen's collars of pine, which swell and close the joint but allow expansion and contraction.

2. (*Masonry.*) The filling in of a hollow or double wall.

3. Air-tight joints for fruit or jam can-covers are made by screwing or clamping the covers upon a gasket of rubber; or wax or resin is run into a crevice. See FRUIT-JAR.

Fig. 3466.

Packing-Awl.

4. Well-tubes are packed by rubber thimbles, inflatable bags filled with air or water, or with flaxseed, which swells as it absorbs water.

Pack'ing-awl. One for thrusting a twine through a packing cloth or the meshes of a hamper, in order to fasten the package by a tie.

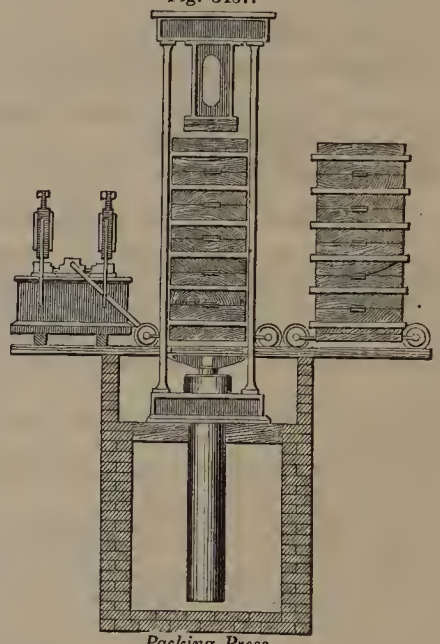
Pack'ing-bolt. (*Steam-engine.*) A bolt which secures the gland of a stuffing-box.

Pack'ing-box. 1. (*Steam-engine.*) A steam-tight composition or systems of parts around the piston-rod of an engine where it passes through the head. A *stuffing-box*.

2. A box for transportation of merchandise.

Pack'ing-press. A press for baling cotton, wool, hay, etc. The power, screw, or preferably hydraulic, is applied to the platen from beneath, and the boxes in which the substance is compressed are provided with hinges and catches so as to be readily taken apart; these are placed one above another on trucks with rollers, which are run under the press for compression,

Fig. 3467.

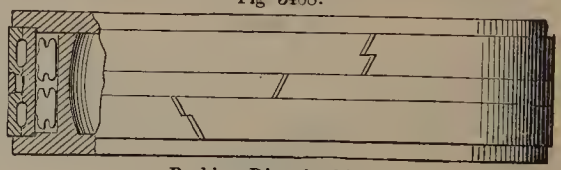


Packing-Press.

and withdrawn when the operation is finished. See BALING-PRESS.

Pack'ing-ring. (*Steam-engine.*) A ring on a piston to expand against the inside of a cylinder and prevent passage of steam. The example shows a set of three rings in which the transverse joints are kept tight by an intermediate ring with inclined edges so fitted between two packing-rings as to

Fig 3468.



Packing-Ring for Piston.

wedge them against the heads of the piston, and pressed outward only by the contact of the packing-rings, the latter being expanded by customary springs. See PISTON; PISTON-PACKING.

Pack'ing-stick. A *woolding* stick; one used in straining a twine around a rolled fleece of wool in tying.

Pack-sad'dle. One constructed for a pack or sumpter animal. It is provided with hooks, rings, and straps to support baggage, stores, or rations.

The pack-saddle for mountain artillery is adapted for transporting a light howitzer, with its carriage and ammunition, when the country is too rough for the passage of vehicles. For this purpose the front and rear of the saddle are made high, and in the form of arcs of a circle, and are recessed so as to readily receive the howitzer, which is lashed on the

saddle, muzzle to the front. The shafts of the carriage are also lashed on the same saddle, the cross-bar resting on the cascabel of the howitzer. The carriage and wheels are carried on a similar saddle upon the back of another mule. The chests containing ammunition are carried by a third animal, one chest being suspended on each side of the saddle. See SADDLE.

Pad. 1. (*Menage.*) *a.* A cushion or stuffing, as that beneath a saddle, to keep the *tree* from galling the horse's back.

Fig. 3469.

Gig-Tree.

b. A cushion beneath a gig-tree of carriage harness, as in Fig. 3469.

c. A saddle without a tree.

d. That part of a double harness to which the girths are attached; used in place of the gig-saddle.

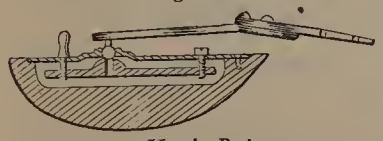
e. A cap of leather, stuffed, buckled over the knee, to keep that part from being grazed or injured by an occasional fall. See LEG AND FOOT GUARDS FOR HORSES.

2. (*Shipbuilding.*) A piece laid over a ship's beam to give the camber.

3. (*Dyeing.*) To impregnate with a mordant.

4. (*Stationery.*) A soft writing surface, as a quarter-quire of blotting-paper, for instance. A *writing-pad.*

Fig. 3470.



Hernia-Pad.

5. (*Surgical.*) *a.* The bag or knob of a truss which rests upon a hernial tumor and prevents its projection.

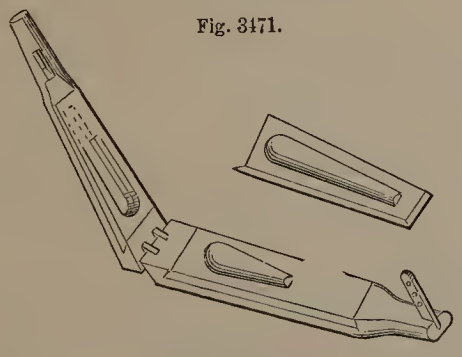
b. A bag or cushion to compress or support a part.

c. A soft wad between the splints and a fractured limb to prevent chafing.

Pad-cloth. A housing-cloth, extending over the horse's loins.

Pad-crimp Press. (*Harness.*) A press in which dampened leather is pressed into shape between protruding and hollow parts of a former. The respective portions are connected by a hinge, drawn forcibly together, pressing the piece of leather into shape, and are thus locked until the leather is dry enough to retain the shape of the mold.

Fig. 3471.



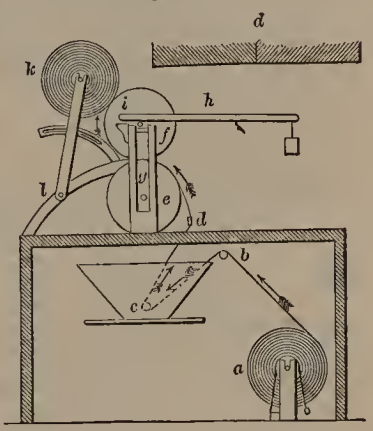
Pad-Crimp Press.

Pad'ding. 1. A method of calico-printing in which the whole surface of the cloth is imbued with a mordant, upon which different colored figures are subsequently raised, by the topical application of other mordants, joined to the action of the dye-bath. Also known as the *plaquage* style.

2. A cloth worked out of rags for stuffing collars of coats, etc.

Pad'ding-ma-chine'. (*Calico-printing.*) An apparatus for uniformly imbuing cotton cloth with a mordant in the process of dyeing.

Fig 3472.



Padding-Machine.

The cloth is wound upon the roller *a*, and is kept tense by a weight passing over a pulley on its axis, and by the roller *b*. It passes through the dye-trough, under the roller *c*, and is pressed against the half-round stretcher-bar *d*, the face of which has diverging grooves which stretch and smooth the cloth previous to its entry between the cylinders *e f*, which are covered with several thicknesses of cotton cloth. The journals of the roller *e* are fixed in the upright standards *g* on either side, while those of *f* admit of vertical movement so that its pressure may be varied by the adjustment of the weighted lever *h*, which is fulcrumed at *i*. The cloth passes obliquely between these cylinders, and is finally wound upon the roller *k* journaled in standards pivotally supported in the arc *l*, so as to allow for increase of size as the cloth winds upon the roller.

Pad'dle. 1. The water-door in a lock-gate or sluice. A *clough.*

2. A float or board of a paddle-wheel.

3. A small scull for propelling a boat or canoe. A short oar, used without being shipped in a row-lock.

4. An iron bar or blade for stirring ore in a furnace.

5. A bat or pallet for working in plastic material.

6. A shovel or scoop to stir and mix materials, as sand with ashes in glass-making.

Pad'dle-box. (*Nautical.*) The upper case of a steamboat's paddle-wheel.

Pad'dle-box Boat. A boat which forms the upper section of the paddle-box, and is launched in case of emergency.

The paddle-box boat of Captain Smith of the English navy forms the top of the wheel-house in its ordinary capacity, being of a size adapted to its position and the size of the wheel. In the "Carron," 250 tons burden, it is 25 feet long, 9 feet beam, and has 4 air-tight cases, which qualify it as a life-boat. When in place, as the roof of the wheel-house, the midship thwarts are unshipped, so as not to be struck by the paddle-wheel, which revolves within six inches of her keelson.

One of the figures shows the boat in position, and the other is a transverse section of the vessel, showing the boat on one side of the vessel, turned over, suspended from the davits, and ready for lowering.

The boat lies bottom upwards on two iron davits having hinges, which enable her to be turned over

and lowered down by six men in three minutes. A boat of similar capacity (capable of containing 40 to 50 men) could not be got out, if stowed in the usual position on deck, under twenty minutes, by

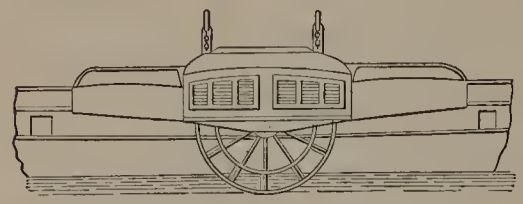
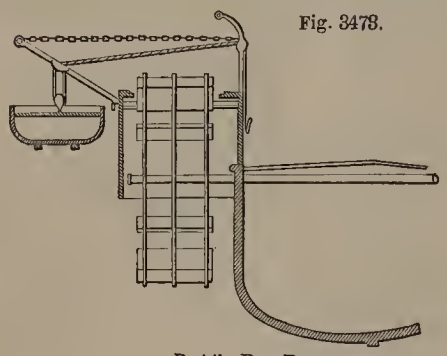


Fig. 3473.



Paddle-Box Boat.

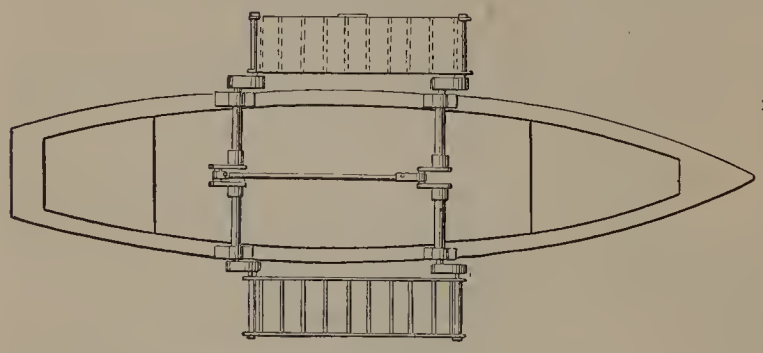
the whole crew; and, in case of fire, probably not at all.

The longitudinal view shows the cabins, cook-houses, etc., before and abaft the wheel-house, similarly covered in.

Pad'dle-hole. (*Hydraulic Engineering.*) A water-channel through which the water passes from the upper pond of a canal to the lock-chamber, or from the latter to the lower pond.

Pad'dle-pro-pel'ler. A form of boat propulsion in which the vertical blades are bolted to a parallel bar and connected to cranks, by whose revolution they are alternately immersed to make the effective stroke and raised clear of the water on the return stroke.

Fig. 3474.



Paddle-Propeller.

Pad'dle-wheel. A water-wheel used in the propulsion of a vessel.

The framework of a paddle-wheel consists of *centers*, *arms*, and *rings*.

The *centers* are *disks* or *bosses*, two or three in number, keyed around the paddle-shaft and having sockets around their rims for the arms.

From each of the *centers* there radiates a set of *arms*, equal in number to the paddles. The *arms* are straight, flat iron bars, so placed as to move edgeways through the water. The outer ends of the arms are T-shaped, and to the cross-bars of each set of arms is riveted an outer *ring* of bar-iron. Inner rings, one or two in number to each set of arms, are riveted to lugs, or projections from the edges of the arms.

The proportions given by Hebert are to make the diameter of the wheel equal to four times the length of the stroke, and the depth of each paddle $\frac{1}{8}$ of the diameter.

The first use of paddle-wheels may have been in the *velocimeters* of the ancients, in which an axis crossed the vessel, projecting over each side, and had paddle-wheels four feet in diameter, which dipped into the water and were rotated by the progress of the vessel. A tooth on the axis worked a train of gearing, so as to drop a ball at every 400th revolution of the paddle-wheel, indicating by sound and count the distance traveled.

Jonathan Hull, in his English patent of December 21, 1736, describes his boat as driven by a fire-engine, meaning a Newcomen atmospheric engine, which rotated "six fanns that turn upon an axis, ... the fanns are brought into and keep a direct motion in the water which forces forward the vessell in which the machine [steam-engine] is placed."

The paddle-wheel has been a favorite subject with inventors, the aim having been to enable it to enter the water without percussion and to leave it without raising a swell.

The greater number of these devices are for feathering the paddles, a subject which belongs to Division 2 (see below).

Some of these devices may be considered under this head, and it may be here stated that the loss of power incident to the obliquity of the blow delivered by the paddle is much exaggerated.

Galloway's patent, 1835, specifies paddles of cycloidal form, which enter the water nearly vertically and avoid concussion. They would probably lift the water when emerging worse than the common float.

Paddle-wheels may be classed under nine different heads: —

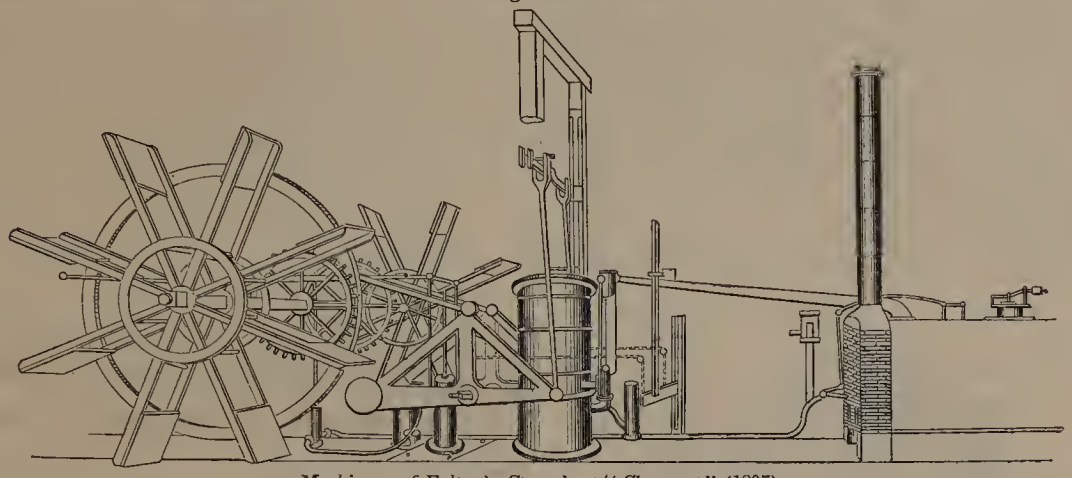
1. Floats fixed on the arms.
2. Feathering floats.
   - *a.* Turning on horizontal axes.
   - *b.* Turning on radial axes.
3. Floats sliding radially toward and from the paddle-wheel shaft.
4. Floats attached to traversing chains.
5. Floats attached to cranks.
6. Collapsing paddles.
7. Floats in reciprocating frames.
8. Sculling paddles.
9. Cycloidal paddles.

Fig. 3475 shows the paddle-wheel used by Fulton on the "Clermont" in 1807. This was the first steamboat which can be called a practical success, she having made regular trips between New York and Albany for several years. The paddle-wheel used by Fulton is of substantially the same form as the one now in general use. See Woodcroft's "History of Steam Navigation."

Gemmel's patent, 1837, is rather a duplication than a change of construction. Two pairs of paddle-wheels are employed, the horizontal steam-cylinders having piston-rods proceeding from each end, and having cross-heads from which connecting rods reach to the paddle-wheel shafts.

2. *a.* Buchanan's parallel float-wheel. The floats are attached to horizontal shafts which have their bearings in the radial arms. On the axis of each paddle is an arm from which a rod proceeds to an eccentric on the paddle-wheel shaft. The effect is

Fig. 3475.



Machinery of Fulton's Steamboat "Clermont" (1807).

to keep the floats vertical at all points of their revolution.

In Galloway's patent of 1829 the revolution of the wheel causes an eccentric collar to rotate by the action of arms, and the radius rods cause each paddle to oscillate on its axis so as to enter and leave the water obliquely.

In Oldham's improvement in 1827, the angle of the paddles is constantly varying, being vertical only at the point of greatest submergence, and horizontal at the point of greatest elevation. The change of position is accomplished by the oscillation of the axis of the float, by means of rods, cranks, and an eccentric wheel on the paddle-shaft.

b. Dawson's feathering paddle-wheel (*A*, Fig. 3476), 1814, has floats attached to radial rods which rotate on their axes so as to enter and leave the water obliquely, but present their full surfaces squarely at the point of greatest immersion. The change is effected by affixing on the axis of each paddle two wipers which cross each other at right angles, the wipers coming in contact with inclined planes which cause the axes to oscillate to the extent of 90°.

Head's improvement, 1828, has two leaves to each float; these open so as not to oppose the action in entering and leaving the water, but during immersion form a combined broad float.

3. Leeming's sliding float (*B*), 1835. The arms are grooved and the paddle-boards slip out and in by the action of an eccentric *c* attached to the side of the vessel.

After its effective stroke each paddle is withdrawn nearly vertically.

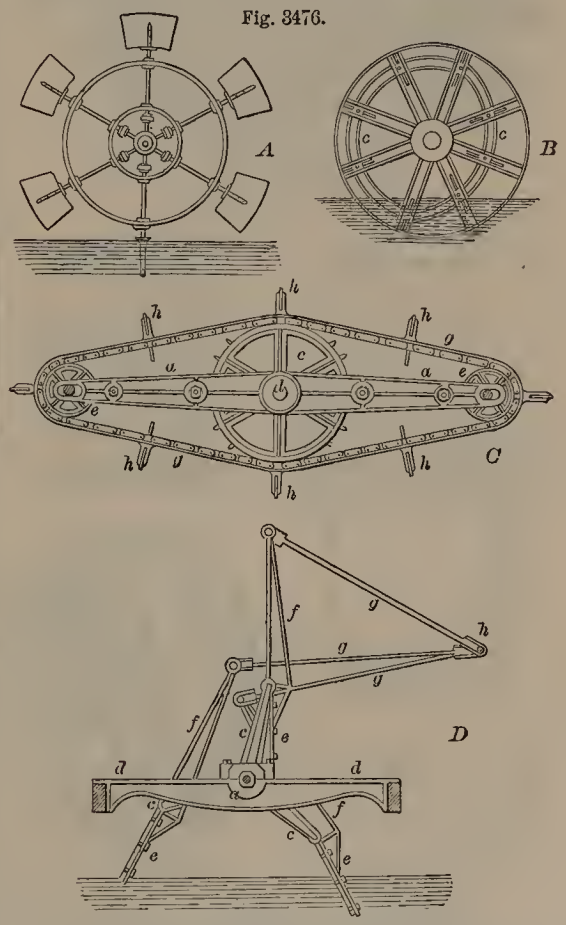
4. Floats attached to endless chains which pass over drums have been used, the intention being to give a direct impulse in the line of the vessel's motion, instead of giving the oblique blow upon the water incident to the ordinary paddle-wheel.

Spurgin's endless-chain propeller (*C*), 1837, passes over three wheels, the larger one being spiked and forming the driving-wheel, while the end wheels are drums which extend the chain and maintain its position; the middle wheel being larger, or having an axis depressed below those of the drums, so as to give a certain obliquity to the floats in entering and emerging.

a a is a cast-iron frame bolted to the side of the vessel; *c* is one of a pair of spike-wheels fixed on the engine-shaft *d*; *e e* are drums running upon the pins or studs on the ends of the frame; *g g* is an endless flat chain passing over the drums *e e*, and over and under the spike-wheel *c*. In order to keep this chain extended, the axes of the drums *e e* move in slots in the frame *a a*, and are keyed up so as to give the requisite tension to the chain. *h h* are the floats, which are carried by iron forks, which are forged in one with the middle links which support them.

5. Stevens's crank-axle paddle (*D*) (English), 1828, has three paddles attached separately to the arms of a three-throw crank, and, by means of radius and guiding-rods connected with them, the paddles are each made to describe in the water the segment of an ellipse.

Fig. 3476.



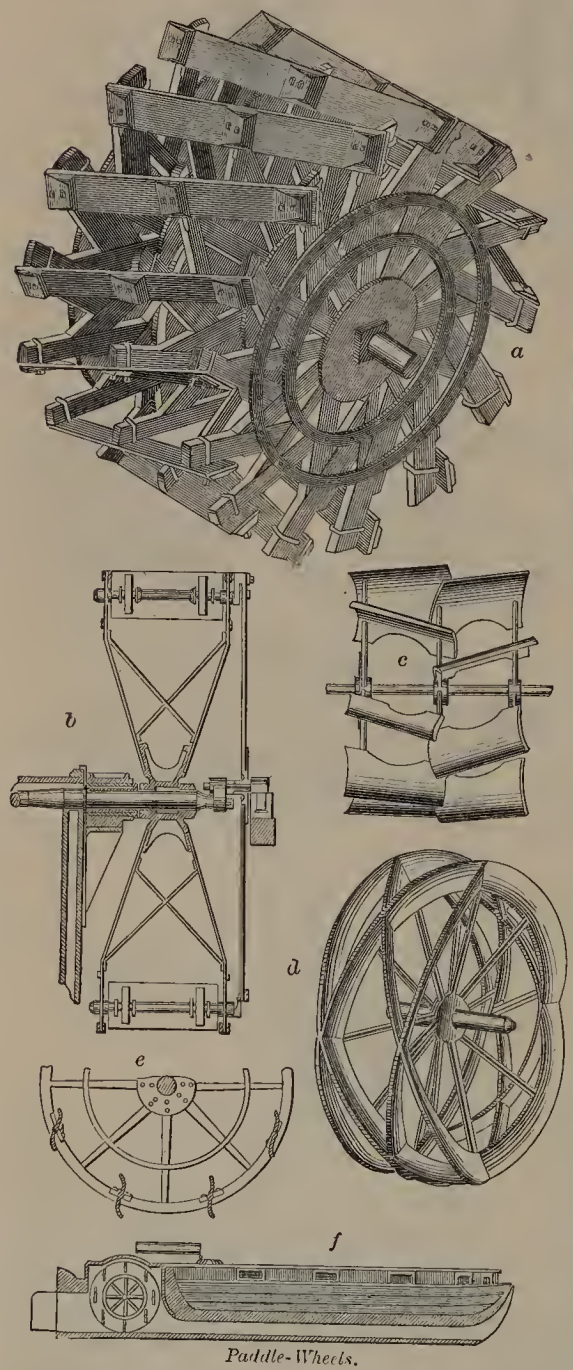
Paddle-Wheels.

a is the axis of a triple crank, the separate arms of which *c c c* move between parallel bars on the side-frame *d d* of the paddle-box. *e e e* are the three paddles connected by the guide-rods *f f f* to the radius-rods *g g g*, the latter working from a fixed beam or center *h*.

6. Nairn's collapsing paddle (English patent, 1828) is allied in principle to the duck's-foot propeller. A number of levers are suspended over the sides of the vessel, extending to any suitable depth. These are made to vibrate by means of the engine, and the feet or paddles on the levers are made to collapse during the non-effective stroke, so as to offer no resistance; but when the effective stroke is made, the float expands, offers its full area to the water, and propels the vessel.

The *duck's-foot* propeller was tried by a Swiss clergyman, named Genevois, about 1737. It was

Fig. 3477.



Paddle-Wheels.

of a contracting and expanding character, and was intended to resemble a duck's foot in its mode of operation. Earl Stanhope revived the idea about 1803.

7. Floats in reciprocating frames. A number of vertical floats are arranged in a frame which moves in one set of horizontal guides while making its effective stroke, the paddles being submerged or nearly so. At the end of its stroke it is lifted out of the water, returned along an upper track, dropped down to its work, and then again propelled.

A number of patents have been granted for modifications of this general idea.

8. Perkins's sculling-wheel, patented in England in 1829, has paddles set obliquely on radial arms which are attached to axes sloping toward the stern, so as to make with the axis of the vessel angles of 45° and an angle of 90° with each other. On the extremities of the axis are bevel-wheels, which are both acted upon by an intermediate wheel driven by the engine.

In Fig. 3477, *a* shows a form of paddle-wheel so constructed that the blades descend obliquely into the water, so that an equal amount of blade-surface is submerged at all times and jar avoided. The position of the arms gives the blades such direction as to prevent them from lifting water.

Feathering paddles are of various forms. The object of feathering the floats is to present them to the water at right angles at all times, and to cause them to enter and leave the water edgewise.

In *b*, Fig. 3477, the floats are operated by rods from an eccentric on the crank-shaft. The crank connection between the controlling frame and guard-beam permits the bearing of the controlling frame to change its position in relation to the guard-beam whenever the latter changes its position in relation to the main wheel. In consequence of the diagonal arrangement of said connection, the controlling frame is moved to the least extent by movements of the paddle-guard in vertical and horizontal directions. The arrangement of the paddle-cranks is intended to equally divide the weight of the controlling frame between the paddle-wheel and the paddle-wheel guard.

c, same figure, gives another form of wheel constructed with the same object in view. The floats are curved as well as set diagonally to the shaft.

d is a form of oblique paddle designed to avoid jar.

e has feathering paddles automatically operated by the pressure of water against them.

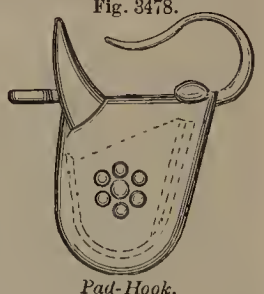
f shows the paddle within the hull, adapted to canal-boat propulsion.

The paddle-wheels of the "Great Eastern" are 56 feet diameter, 13 feet deep, 30 floats or paddles.

Pad'e-soy. (*Fabric.*) See PADUASOY.

Pad-hook. (*Saddlery.*) A hook on the back-pad to hold up the bearing-rein.

Fig. 3478.



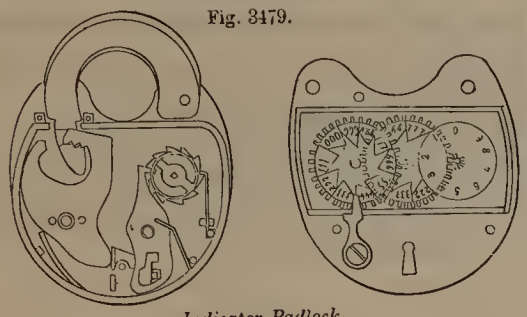
Pad-Hook.

Pad'lock. A lock with a bow to hold on to a staple. Made by Beehar at Nuremberg, A. D. 1540. Dr. Abbott's collection of Egyptian antiquities in New York contains a padlock found in a tomb at Sakkarah. They were also used by the Romans.

Fig. 3479 is an example of one in which the key, on being inserted, acts first on the tumblers, so as to free the cylinder and to allow a slide to be raised, and it then raises the slide so as to turn the cylinder. The slide-bolt is replaced in its original position by the turning back of the key after the lock has been opened.

Fig. 3480 is a combination padlock having a number of disks which must be brought into coincidence to allow the bolt to be withdrawn from the hasp. The disks are numbered on their peripheries, and

Fig. 3479.

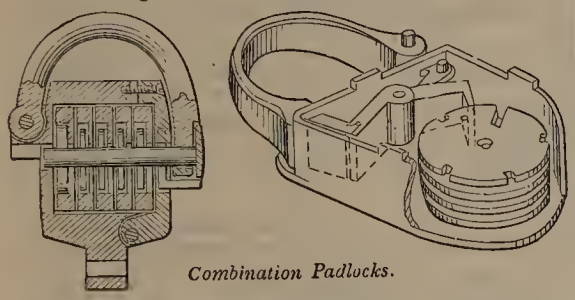


Indicator Padlock.

perforated with central holes and radiating slots for the passage of the bolt. The bolt has an axial bar and radial arms. The arms having passed through the slots in the disks, the latter are disarranged and oppose the withdrawal of the bolt. A screw under the shackle fastens the lid, which may be opened to remove and rearrange the disks.

Fig. 3481 is a perspective view of another combi-

Fig. 3480. Fig. 3481.



Combination Padlocks.

nation lock. In closing the hasp its shank acts against the lock-bolt and interlocks with the latter while withdrawing its dog from the gateways of the tumblers; hence, in order to lock the hasp, it is only necessary to break up the combination by turning a thumb-screw.

Pad-plate. (*Harness.*) An iron bow, either malleable or wrought, upon which the pad is made, answering the double purpose of giving stiffness to the pad and as a means of attaching the mountings.

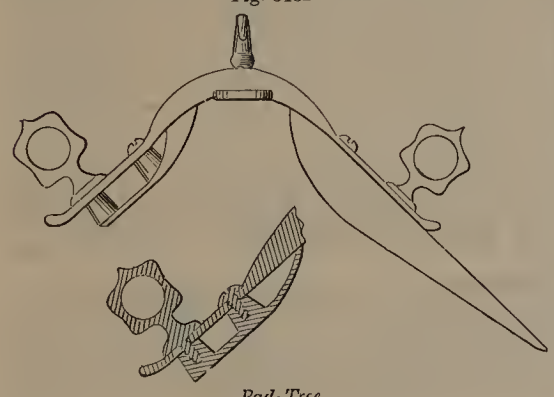
Pad-sad'dle. (*Harness.*) A saddle made of leather and padding without any *tree*.

Pad-screw. (*Harness.*) *a.* A screw-bolt having an ornamental head, used for securing the pad-sides to the pad-plate, and as an ornament.

b. A screw to hold the *tug-strap* and *gig-flat* together.

Pad-side. (*Harness.*) The strip of leather attached to the end of the pad, which furnishes a portion of the girth to hold the latter in its place.

Fig. 3482.



Pad-Tree.

Pad-top. (*Harness.*) The ornamental leather that forms the top or finish to the pad.

Pad-trace Bear'er. (*Harness.*) A strap attached to the outside of the pad-side under the end of the pad-top, and extending down outside the pad-side to permit the trace passing between it and the side; used in double harness only.

Pad-tree. (*Harness.*) A piece of wood or metal which gives shape and rigidity to the harness-pad.

Pad-u-a-soy'. (*Fabric.*) A kind of silk.

Pæ-dom'e-ter. An instrument for measuring the length of children.

Page. 1. One side of a leaf in a book.

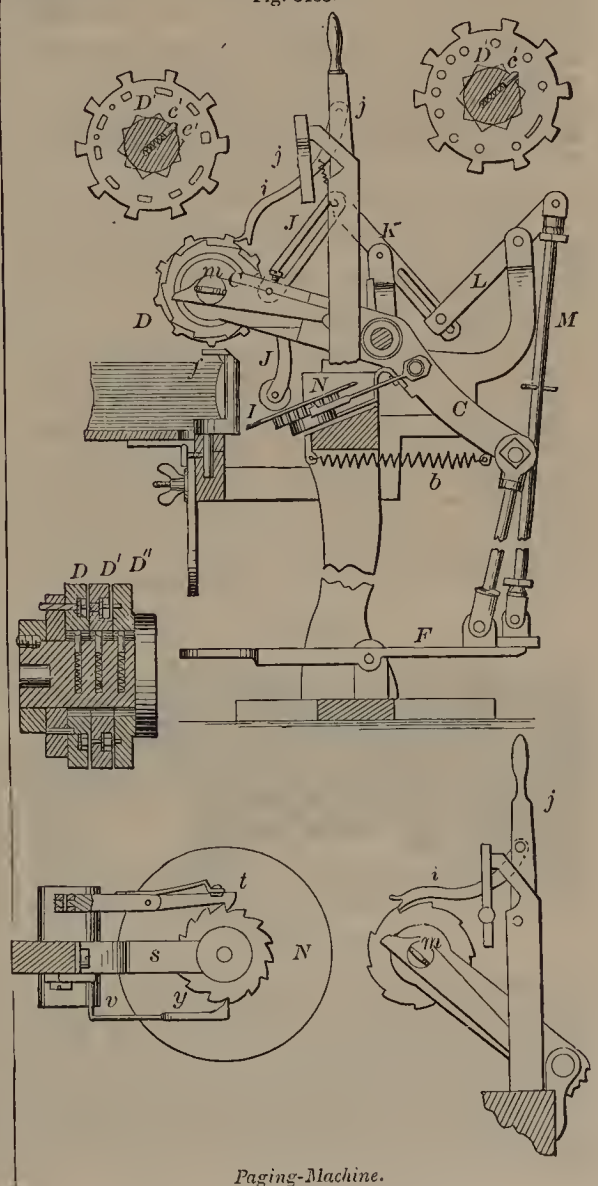
2. The track carrying the pallets, which support the newly molded bricks, and on which they are slipped to the off-bearing boy who stands at the end. See BRICK.

Page-cord. (*Printing.*) Strong, smooth cord, cut in suitable lengths to tie up a page of type. It is wound three or four times about the type, and the ends tucked under, not tied.

Page-gage. (*Printing.*) A standard of length for the pages of a given piece of work, to keep them uniform.

Pag'ing-ma-chine'. (*Printing.*) A machine

Fig. 3483.



Paging-Machine.

for giving the consecutive numbers to the pages of an account or blank book. Also used, under the name of a *numbering-machine*, for giving the successive numbers to tickets, cards, checks, etc.

In one form the numbers are presented on disks which combine to form a cylinder. This is driven down upon the paper, delivering an impression. The unit-wheel is then turned a notch, which shifts the number one point, and another impression is given. The numbered disks are connected in series, as in REGISTERS, ARITHMOMETERS, GAS-METERS, etc. (which see).

Fig. 3483 shows a common form of paging-machine for printing the same number or a succession of numbers on sheets or leaves which are fed to it. The figures are on the circumference of disks *D*. These are mounted on shaft *m* in such a manner that they revolve independently of it. The disks are held above the paper *f* by the force of a coiled spring *b* at the other end of pivoted arm *C*. Pressure of the foot upon the treadle end of lever *F* brings down the face of the type on the sheet, and at the same time throws back the inking-roller *I* upon the ink-distributing disk *N*. When the pressure upon the treadle ceases, the type-disks rise, and the inking-roller passes across their lower face by the action of toggle levers *J K*, *L M*. The figure on the units disk is at the same time shifted by the pawl *i*, operated by lever *j*, acting on the ratchet-wheel, or this part may be thrown out of gear and the same number retained. Each revolution of the units disk moves forward the tens disk one figure, and so on.

The ink distribution is effected by the revolution of disk *N* through the mechanism *s t v y*, shown in one of the detached figures.

Disks *D D' D''* may be shifted to the extent of two figures when it is desired to have a series of alternate figures, as in paging the right or left hand pages of a book.

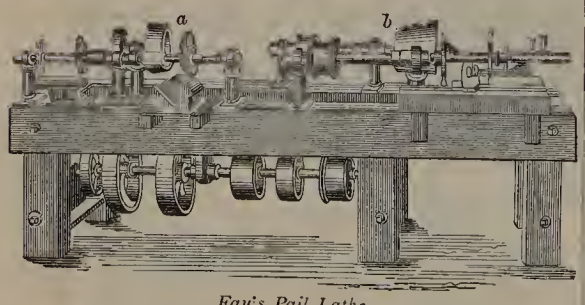
The disks are held in their places by a catch working in notches *c'*. An extra notch *e'* is provided, not in line with any figure of the disk, by which means the latter may be held to such a position that none of its type will print.

By the use of a machine of this class, an expert can number the pages in a book as rapidly as the leaves can be turned. The mechanical adjustment of the figures insures extreme accuracy in numbering a series of papers.

Pail-lasse'. An under-bed of straw. The form and purpose being retained, other materials have been substituted, as moss, finely shredded wood, called *excelsior*, corn-husks, sponge, hair. A *mattress*.

Pail-lathe. One in which buckets are turned on the outer and inner sides and the ends trued, dressed, and the croze made. The lathe shown in Fig. 3484 has two portions, *a* and *b*. The staves for a pail being assembled and held by a truss-hoop, the pail is placed on the chuck *a*, while the outside is turned off smooth and one end dressed, the hoop

Fig. 3484.



Fay's Pail-Lathe.

being shifted once so as to reach the whole surface. The pail thus dressed on the outside and one end is then stuck into the hollow chuck *b*, which holds it while the inside is turned smooth and the other end shaped and dressed. Operating on each end of head *a* are circular saws, whose distance apart is equal to the hight of the pail, and these act simultaneously, to saw off the ends.

Pail-ma-chine'. A bucket-making machine. See PAIL-LATHE.

Pail-nail. A kind of nail used in making some kinds of buckets.

Paint. 1. A pigment, white or colored.

The colors used by painters are principally derived from the mineral kingdom, though animal and vegetable substances are to some extent employed. The following tabular statement indicates the composition of those most generally used.

	Name.	Composition or Derivation.
White.	White lead	Carbonate of lead.
	Zinc white	Oxide of zinc.
	Spanish white	Purified carbonate of lime.
	Sulphate of baryta	
Yellow.	Yellow ochre	An earth composed of silica and alumina, colored by oxide of iron.
	Naples yellow	Antimoniate of lead.
	Chrome yellow	An impure chromate of lead.
	Gamboge	A gum principally derived from Siam.
Blue.	Ultramarine	From *lapis lazuli*; also prepared artificially.
	Cobalt blue	Phosphate of alumina and oxide of cobalt mixed with arsenite of cobalt.
	Smalt-Saxon blue	Double silicate of cobalt and potassa, mixed with earthy and metallic oxides.
	Antwerp blue	Prussian blue with various proportions of alumina and carbonates of magnesia and zinc.
	Prussian blue	Ferro-cyanide of iron.
	Berlin blue	
	Indigo	From plants of the genera *indigofera*, *isatis*, and *nerium*, principally the former.
Black.	Lampblack	Carbon from the soot of burning rosin or other vegetable or animal matters.
	Ivory black	Calcined wine lees.
Red.	Red ochre	From calcination of yellow ochre.
	Red lead or minium	A mixture of protoxide and binoxide of lead.
	Madder	From the madder plant, *rubia tinctoria*.
	Cochineal	The dried bodies of the cochineal insect.
	Vermilion	Cinnabar, a sulphide of mercury, natural or prepared.
Green.	Chrome green	Sesquioxide of chromium.
	Schweinfurt green	Acetate and arsenite of copper.
	Scheele's green	Arsenite of copper.
	Verdigris	Acetate of copper.
Brown.	Terra di Sienna	A natural earth found in the vicinity of Sienna, Italy; when burned it forms a red.
	Umber	An earth from that part of Italy anciently forming the Roman province of Umbria.
	Bistre	Soot of wood, preferably beech.

Numerous other colors are used by artists for producing different shades, and a large list might be made of those employed in dyeing and paper-staining, each having its peculiar fitness for special purposes. Among these, the various shades of violet, blue, green, red, etc., derived from aniline, a product of petroleum, have of late years assumed great importance. See ANILINE-COLORS; DYEING; WATER-COLORS.

2. (*Rubber-manufacture.*) Stuff mixed with caoutchouc in the process of manufacture, and intended to harden it. Sulphate of zinc, whiting, plaster-of-paris, lampblack, pitch, and other materials are used.

Paint-brush. Paint-brushes are generally made of hogs' bristles, but for artistic purposes the hair of other animals, as the fitch, badger, sable, and camel, is employed. Paint-brushes are commonly either round or elliptical in cross-section; the latter

are usually made of the best bristles, and are termed varnish-brushes.

In one method of attachment the handle is round, and its enlarged base has a prong on each side between which the thick ends of the bristles are inserted, and afterward secured by a wrapping of twine which is coated with glue mixed with red-lead.

Another way is to insert the tapering handle, around which the bristles have been previously fastened by wrapping, into a metallic cap; the handle is then driven home, so as to firmly hold the bristles between it and the cap.

Smaller brushes of this kind are known as sash-tools, fitches, lettering-brushes, etc., according to size, shape, or material. Graining-brushes, called blenders, are made of camel's hair, and are flat in shape.

James Watt recommended rats' whiskers as the best material.

Various other modes of securing the bristles have been tried.

In Fig. 3485, the metallic top has upper and under sockets, in the former of which the handle is inserted. The latter contains the bristles, which are held in place by a wedge *D* drawn upward by a screw, which also serves to secure the handle.

Fig. 3485.

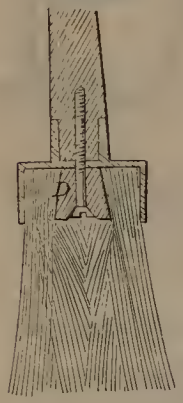


Fig. 3486.

Paint-Brushes.

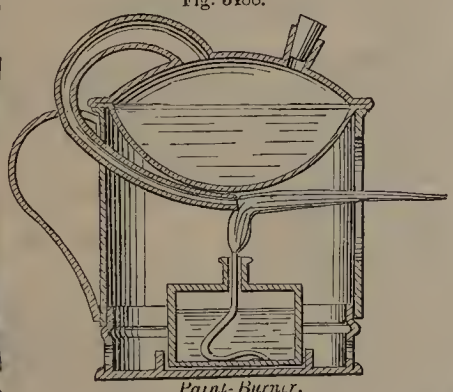
In Fig. 3486 the bristles are secured between the butt of the handle and an open ring *C*, the ends of which are drawn together by a screw passing through two lugs.

In Fig. 3487, the end of handle *C* is provided with a screw-thread, and is made hollow to receive the shouldered wedge *B*; the bristles being inserted in the tubular top *b*, the wedge is forced in between them by screwing the handle *C* into place, causing them to be firmly retained between the wedge and the outer tube.

Fig. 3487.

Paint-Brush.

Fig. 3488.



Paint-Burner.

Paint-burn'er. A blowpipe and lamp by which a flame is directed upon paint, to burn it off and prepare the surface for a new coat. In the example, the alcohol furnishing the vapor for the blowpipe is contained in the retort above the lamp.

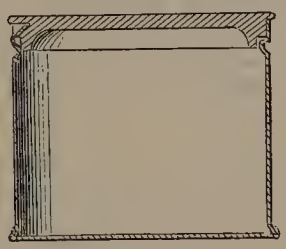
Paint-can. A can specially constructed for holding paint. For convenience, paint is usually sold in cans of given capacity, and ingenuity is exercised in devising means for cheaply and securely closing, enabling them to be readily opened and conveniently used as paint-pots. Fig. 3489 has a removable cap.

Fig. 3489.

Paint-Can.

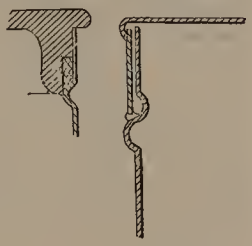
Fig. 3490 has an inwardly projecting bead to hold the gasket on which the cover rests. The cover has notches into which the rim of the metallic can is pressed to fasten the cover.

Fig 3490.



Paint-Can.

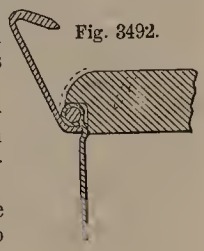
Fig. 3491.



Can-Lid.

In Fig. 3491, the can has protruding and intruding circumferential heads. The rim of the cover fits down over the latter and forms an air-tight closure; being cut around at that level, it subsequently forms a lid.

Fig. 3492.



Lid-Fastening.

In Fig. 3492, the hooks are soldered to the upper part of the can and turned over, so as to penetrate and hold the wooden cover.

Paint'er. (*Nautical.*) *a.* The bow rope which fastens a boat to a wharf or alongside a ship.

b. A rope by which the shank of an anchor is secured to the gunwale. It is made partly of chain. A *shank-painter.*

Paint'ing. (*Fine Arts.*) The art of covering surfaces with pigments for decoration and protection; also the representation of objects in their natural colors by similar means.

In house-painting, the pigment most extensively used is white-lead. This is white, but it may be tinged with other ingredients to form grays, blues, and yellows of various shades, as well as many other colors. Zinc-white is also largely used, but does not possess the "body" of white-lead, requiring more to cover a given surface. Ochres and other earthy minerals are employed for forming different tints, of yellow, brown, and dull red. Other oxides and salts of lead, mercury, chromium, iron, and copper, form reds, greens, blues, and yellows. The impalpable powders derived from the smoke of some vegetable and animal products constitute different grades of blacks. See PAINT.

Any intermediate tints may be produced by the judicious intermingling of these principal colors. These are mixed with linseed-oil, either raw or boiled, to which, for most purposes, a greater or less proportion of spirits of turpentine is added. Rapid drying is insured by the addition of a small proportion of litharge, sugar of lead, or Japan varnish, according to material or color.

Painting as a fine art probably originated at even

an earlier period than its employment for preservative purposes, having been derived from the practice, almost coëval with the introduction of man on the earth, of sketching the outlines of animals and other objects on hard substances; outline drawings of the extinct elephant and rhinoceros having been found engraven on bone in caverns, the condition and contents of which indicate that in some parts of Europe they were contemporaneous with man at a period prior to the glacial era. From outline to monochromatic painting was but a step; shading, to produce the appearance of relief in rounded and projecting parts, and the employment of differently colored substances to imitate their natural hues, gradually followed.

The ancient Egyptians appear to have never advanced beyond the last step, shading having been unknown until introduced by the Greeks, whose esthetic minds improved and beautified every art which they borrowed from others. Such of their works as remain do not enable us to judge how far their knowledge of perspective had advanced, but it does not seem to have been reduced to an exact and systematic science among them.

The enamel, encaustic, and fresco work of the ancients has come down to us in profusion. Their paintings on paper, canvas, leather, and wood have mostly perished. The even climate of Egypt and the seclusion of the tombs excavated in the rock by its ancient inhabitants have, however, preserved many specimens of their painting on wood and fabric in the mummy cases and wrappings.

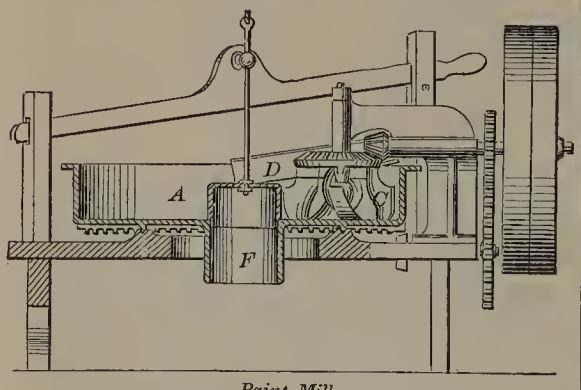
The bricks of Mesopotamia and the pottery of Etruria are also very ancient and interesting, the latter especially exhibiting a refined taste.

The modes in which colors may be applied to produce various effects, and possess more or less endurance, are described under DESTEMPER, ENCAUSTIC, ENAMEL, GLASS, OIL, SIZE, WATER-COLORS. See list under FINE ARTS.

Paint-mill. A machine for grinding pigments.

In Fig. 3493, a circular pan *A* containing the paint is rotated by appropriate mechanism, while stirring

Fig. 3493.



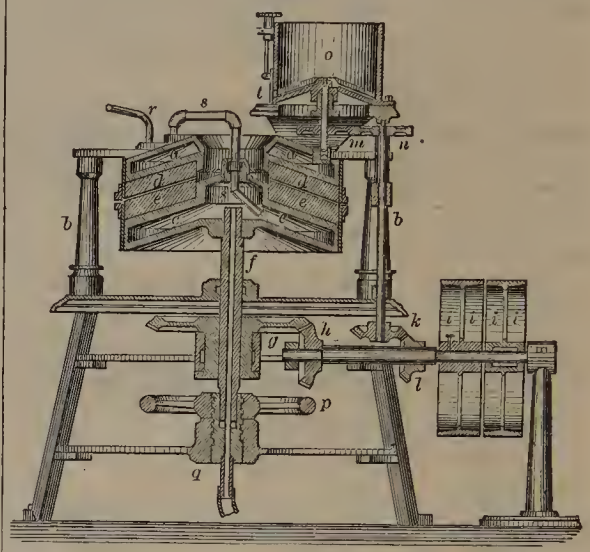
Paint Mill.

and scraping feet are caused to revolve therein by means of bevel-gearing. The discharge is effected by a curved scraper *C*, which brings the mass to a central opening *F*, provided with a tubular cover or valve *D*.

In Masury's paint-mill the upper millstone bed *a a* is supported on pillars *b b* bolted to a cast-iron table; both the upper and lower beds *a a c c* are hollow and receive thin annular disks of stone *d d e e*; the lower is supported on a hollow shaft *f* rotated by the bevel-gears *g h*, driven by the pulleys *i*, which also, through the medium of bevel-gears *k l* and spur-wheels *m n*, turn an arm in the mixer *o*.

The lower stone is raised into contact with the upper one by turning the wheel *p*, which raises the screw-step *q* of the hollow shaft *f*, which slides through the bevel-wheel *g*. The stones are cooled by water admitted through the pipe *r* to the open space *a a*, whence it passes through the pipes *s s* to the open space *c c* in the lower bed, and is discharged through the tubular shaft *f*. The material to be ground is placed in the mixer *o* and gradually fed into the mill through a small opening *t* provided with a gate for regulating its flow; the lower stone is

Fig. 3494.



Paint-Mill.

brought into the required proximity with the other in the way above described, and a continuous flow of water allowed to circulate through the hollow spaces within the beds; by this means the particles of paint may be ground to an extreme degree of fineness without material evolution of heat. Mills constructed on this principle may also be used for grinding other substances.

Pair-horse Har'ness. The general name given to double harness in England.

Paix'han Gun. A large chambered shell-gun, so called from Colonel Paixhan of the French army, who introduced it in 1822.

Guns of this kind of the caliber of 8 and 10 inches, known as sea-coast howitzers, formerly constituted a part of the armament of coast fortifications in the United States. These differed from the *columbiad*, invented by Colonel Bomford, United States army, about 1812, in being lighter in proportion to their caliber and in having no elevating rack on the cascabel, and have been superseded by ordnance of more modern forms. See CANNON.

Pa'la. (*Nautical.*) The blade of an oar. The *wash*.

Pal'ace-car. (*Railway Engineering.*) A car fitted with first-class accommodation, sofas and chairs, instead of the ordinary seats. The car is usually fitted for conversion into berths or couches for night traveling. See SLEEPING-CAR.

Pal'an-quin'. A carriage borne by men who relieve each other at intervals. It is an ordinary mode of conveyance in India and China.

Fig. 3495.

Palanquin.

Pal'ate, Ar'ti-fi'cial. A plate applied in cases of cleft palate, to improve articulation. It consists of an aluminium, gold, silver, or rubber plate, accurately fitted, to close up the opening in the roof of the mouth.

Pale. 1. A kind of fencing consisting of vertical slats supported by posts and rails, or posts and wires. *Paling.*

2. (*Shipbuilding.*) One of the interior shores for steadying the timbers of a ship while building.

Pal'ette. 1. (*Painting.*) A thin oval plate of porcelain or other material, having a hole near one edge through which the thumb may be inserted, used by painters in oil for rubbing-up or holding colors.

2. (*Metal-working.*) The breastplate against which the person leans to furnish a pressure for the hand-drill. Sometimes called a *conscience.*

3. (*Surgical.*) *a.* A light wooden spatula used for percussion, to excite the tone of the skin and tissues.

b. A splint to hold a burnt hand in shape and prevent deformation by the cicatrices.

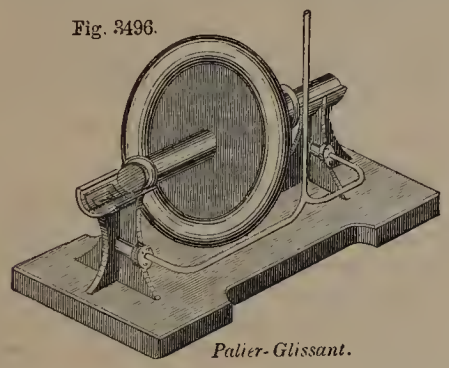
c. An instrument composed of two perforated plates to catch and withdraw the stylet in operations for *fistula lachrymalis.*

Pal'ette-knife. A flat, thin, flexible knife with a rounded end, used by painters to mix colors on a palette, or on the grinding slab. A *spatula.*

Pal'ier-glis'sant. A "slippery support" for a shaft or axle, a film of water being introduced beneath it by pressure. It is described for vertical and for horizontal shafts in Bramah's planing-machine, English patent, 1802. The inventor makes it adjustable by pumping in water *ad lib.* See HYDRAULIC PIVOT; WATER-BEARING.

In Girard's palier-glissant the water, under a considerable head of pressure, is introduced beneath the

Fig. 3496.



Palier-Glissant.

journal, lifting it slightly from its bearings; after two or three oscillations the journal assumes its proper bearing on the box, the water flowing between them in a continuous and almost infinitesimally thin sheet. The comparative friction of this and a bearing lubricated by oil may be tested by imparting rotation to two wheels journaled, one in each way, by hand, when that provided with the palier-glissant will be found to maintain its rotation much longer than the other; if, however, the supply of water be cut off, the wheel immediately stops.

Pal'imp-sest. A piece of parchment whose original writing has been removed in order to fit it for a subsequent record. Many old documents were thus obliterated, and the writing is restored by an infusion of gall, dilute hydrochloric acid, oil, etc., a certain trace of the materials of ink remaining in the substance of the parchment which acts upon the substance applied.

Pal-i-sade'. (*Fortification.*) A row of stakes set firmly in the ground and presenting a sharp point to an advancing party. The stakes are placed vertically at the foot of the slope of the counterscarp, or presented at an angle at the foot of a parapet, or on the banquette of the covered way.

Pal-i'ta. A light shovel. A trowel.

Pal-la'di-um. Equivalent, 53.3; symbol, *Pd.*; specific gravity, 11.8; difficult to fuse. Discovered by Dr. Wollaston in 1803.

It is a white, malleable, ductile, hard metal; fusible with the oxyhydrogen blowpipe.

The alloy of palladium and silver is eminently suitable for the graduated circles of mathematical instruments.

Palladium was used in constructing the balances for the United States Mint, and has been used for the medals of some learned societies.

Palladium alloyed with silver and copper makes an elastic, non-tarnishing blade capable of high polish.

Pal-la'di-um-iz'ing. A process for protecting iron by means of a thin coating of palladium, in lieu of zinc, as in the so-called "galvanizing" process.

The articles to be protected are first cleansed, as in zincking, by means of the double salts of zinc and ammonia, or of manganese and ammonia, and then thinly coated with palladium, applied in a state of amalgamation with mercury.

Pal'lam-poor'. A style of East Indian cotton chintz, printed in large-sized pieces and used for counterpanes. The printing is in the *resist* style, a substance being painted on the cloth having the power of *resisting* access of the dye to the fabric. With the *pallampoor* cloth this was softened wax laid on with a hair-pencil. We have no means of ascertaining how long this style of the art has been practiced, but it seems to be as old as Pliny. Madras has long been famous for this manufacture. One piece 5½ yards long by 2½ broad (French yards) is mentioned by Ure: "said to be the labour of Hindoo princesses, which it must have taken a lifetime to execute."

Pal'let. 1. (*Machinery.*) A click or pawl to which a reciprocating motion is imparted, and by which an intermittent rotary motion is communicated to a wheel, as in many feed motions; or by which the rotary motion of a wheel is made intermittent.

2. (*Horology.*) In an escapement, a lip or leaf connected with the pendulum, or upon the arbor of the balance-wheel, as the case may be, and acting consecutively upon the teeth of a wheel which is driven by the main-spring or weight, and is known as the *scape*-wheel.

3. One of the series of disks or pistons in the chain-pump or chapelet.

4. A bed; a mattress; a palliasse.

5. (*Painting.*) An oval board or piece of ivory to hold paint. A *palette.*

6. (*Nautical.*) A ballast-locker in the hold of a small vessel.

7. (*Clay.*) *a.* A board on which a newly molded brick is carried away to the *hack.*

b. A potter's wheel.

c. A paddle used in beating and shaping plastic material in forming crucibles, etc.; or in taking up mortar for use.

8. (*Bookbinding.*) *a.* A tool for gilding the back over the bands.

b. The instrument with which gilders take up gold-leaf from the pillow.

Pal'let-mold'ing. (*Brick-making.*) As distinguished from *slop*-molding. The bricks are turned out of the mold on to a piece of board of somewhat larger area, called a *pallet,* and on this they are removed to the drying-ground. In pallet-molding the molds are usually sanded; in slop-molding they are wetted.

Pal-li-asse'. (Fr. *Paillasse.*) An under bed of straw. A straw mattress.

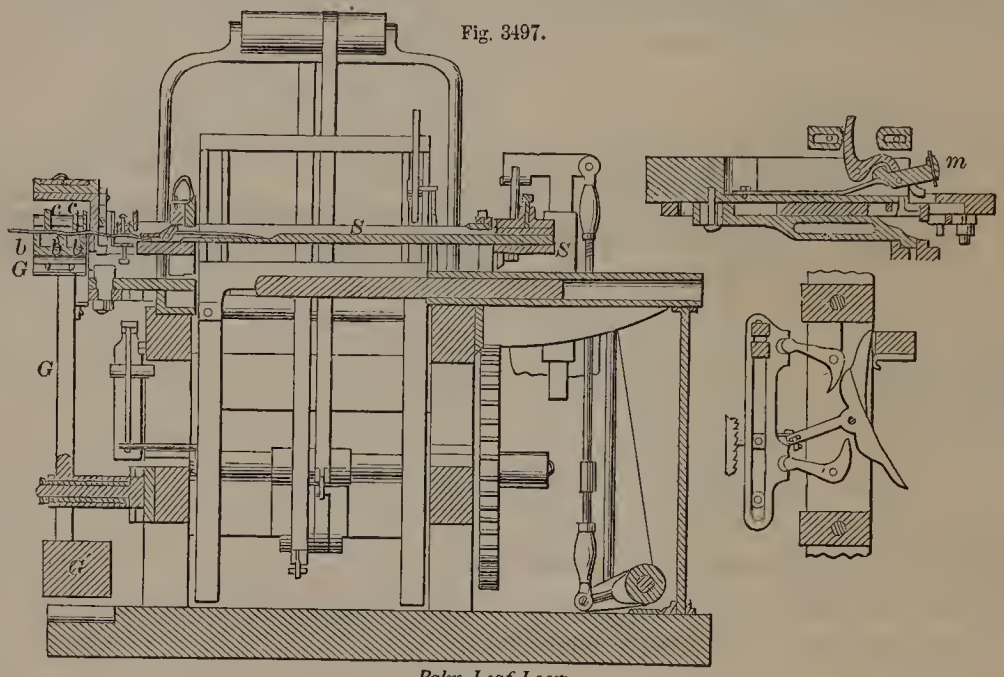
Palm. 1. (*Nautical.*) *a.* The sailmaker's substitute for a thimble. It goes over the hand, and has a fitted shield by which the needle is pushed through the canvas.

b. The flat face of an anchor-fluke which forms the holding surface. See ANCHOR.

2. The breadth of the hand, four inches.

Palm-leaf Loom. Strips of palm-leaf of proper width and length for the weft of the desired fabric are placed side by side between fingers *b c* at the top of a vibrating holder *G* at the side of the loom-frame. The ends of the strips next the selvedge are cut off evenly by a knife, and a weight *G'* at the bottom of the holder keeps the holder pressed in one direction

Fig. 3497.



Palm-Leaf Loom.

with sufficient force to keep the edge of the strip to be selected against a gage about in line with the selector. A feeding-arm *m* catches the end of one strip at a time and presents it to the selector *S*, which has at one end a pair of pinchers, and the selector draws the strip between the warps. The weaving mechanism is as usual.

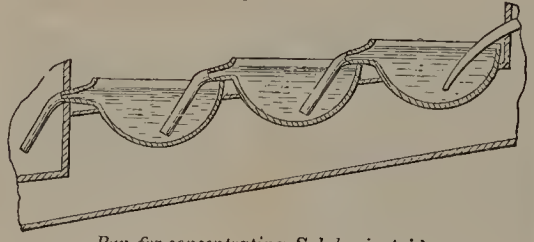
Palm-tree. (*Pyrotechnics.*) A device consisting of a series of green fires on a frame representing the body and head of a palm-tree. It was first designed by the Roman pyrotechnist Ruggieri: the composition is crystallized verdigris, 4; sulphate of copper, 2; sal-ammoniac, 1: ground with alcohol and used to saturate cotton rovings, which are festooned about the frame, and fired before the spirits have evaporated.

Pam'phlet. (*Printing.*) A work consisting of more than one sheet and not over five. It has a paper cover, if any.

Pan. A vessel for boiling or evaporating. Originally an open metallic vessel in which sirups or solutions are boiled for the purpose of concentration or crystallization, as a *sugar-pan*, *salt-pan*, etc. See EVAPORATING-PAN.

The purpose being maintained, closed vessels for the same purpose are also called *pans*. See VACUUM-PAN.

Fig. 3498.



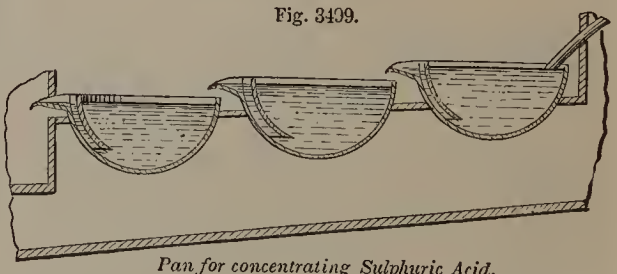
Pan for concentrating Sulphuric Acid.

The shape being preserved, open vessels in which the contents are not heated are called *pans*, as an *amalgamating-pan* (see AMALGAMATOR), *prospecting-pan* (see GOLD-MINING).

1. Overflow furnace-pans are used in concentrating sulphuric acid. In Fig. 3498, the upper pans discharge by pipes near the bottom of the next pan in the series. The effect is to move the whole contents of the pan below.

In Fig. 3499, each pan overflows into the one next below, and by means of the partial partition and spout the liquid is taken from the bottom of

Fig. 3499.



Pan for concentrating Sulphuric Acid.

the pan, where it is in the most concentrated condition.

2. (*Soap-making.*) Soap-pans are made with a wooden frame and an iron bottom; called, respectively, the *curb* and the *pan*.

The same device is used for the preliminary heating and partial condensation of the sugar-water or maple sap, as it is variously called in different sections of the United States.

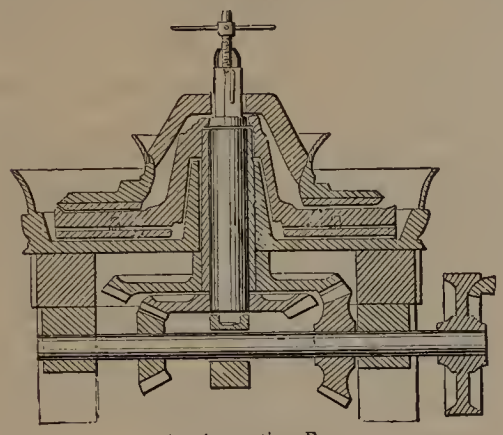
3. (*Tin-plate Making.*) A cold pot with a grating at the bottom in which tinned iron-plate is put on edge to drain and cool. It is the fourth in the series of iron pots and pans used in the manufacture

of tin-plate. *Tin-pot, wash-pot, grease-pot, pan, list-pot.* See TIN-PLATE.

4. (*Metallurgy.*) A name applied to that description of amalgamator consisting of an open metallic vessel in which the comminuted ore and quicksilver are ground together by rotating mullers. There are many varieties, which are described under the *Pan Process.* See AMALGAMATOR.

In the example, the pan has a central conical hub, through which a hollow shaft passes. On the lower part of a spindle which passes through a hollow shaft is keyed a bevel-wheel, and on the lower part of the said shaft is also keyed a similar bevel-wheel, and into these wheels beveled pinions gear, by means of which the mullers are rotated in opposite directions. On the upper part of the hollow shaft a square is formed, which is above the conical hub, and on this square is fitted the square portion of a conical hub, which extends down over the hub and is connected

Fig 3500.



Amalgamating-Pans.

with the muller, which is provided on its under face with shoes. A sleeve provided with a slot is fitted over the upper end of the spindle, and a pin passes through said slot and spindle. This pin and openings cause the spindle to rotate the sleeve, while the openings allow the said sleeve to be adjusted by means of a screw.

5. The powder cavity of the old flint-lock fire-arm.

6. (*Carpentry.*) The socket or sole for a hinge.

Pan-a-ma′ Hat. A leaf hat made in Ecuador and New Grenada of the undeveloped leaf of the "bombonáje" (*carludovica palmata*), which is a screw pine rather than a palm. The trunk of this plant is only a yard in hight, but the leaf-stalks are two yards in length. The bark of these leaf-stalks is woven into baskets, and the expanded leaves are used for thatching. It is the leaf before it has opened that is prepared for the manufacture of hats. It then consists of a bundle of plaits about two feet long and one inch in diameter. The green outside of this "cogollo" or bunch is stripped off; and then, by an instrument called a "picadera," resembling a pair of compasses with legs set half an inch or less apart, according to the fineness of the straw required, the leaflets are made into strips of uniform size with parallel sides. The cogollo is then boiled to toughen the fiber, and hung up in the sun to dry and whiten, when the leaflets run up into cordlike strands, which are then ready for use. The longest straw which can be procured from the bombonáje is twenty-seven and a half inches. It takes sixteen cogollos for an ordinary hat and twenty-four for the finest; and a single hat is plaited in from four days to as many months, according to texture. — PROFESSOR ORTON of Vassar.

Pan′cake. (*Leather.*) A factitious leather made of scraps agglutinated by cement or glue, and pressed into a flat cake for insoles, etc.

Pan-de′an Pipes. The emblems of Pan, the rural divinity of the Greeks, were a shepherd's crook and a pipe of seven reeds. Fig. 3501.

The reeds are bound together in a parallel series, the mouths on a level and the lengths so proportioned as to give the notes of the gamut.

Pandean Pipes.

The instrument yet survives in England as an accessory to the exercises of Punch, playing the air to a base-drum accompaniment. See SYRINX.

A porcelain representation of the Pandean pipes was found by Dr. Abbott at Sakkarah.

Pan-dore′. (*Music.*) A rebec. A kind of lute. See *Pandura*, Plate LI., Bonanni's "Istromenti Armonici," Roma, 1776.

Pane. 1. A compartment or square.

a. A sheet or light of window-glass occupying one opening in a sash. In the *apodyterium* of a Pompeian bath was a pane of cast glass 2 feet 8 inches by 3 feet 8 inches. In the *tepidarium* was another window with four panes.

b. One square of the pattern in a plaid or checker-work fabric.

c. One of the sides of a roof, tower, spire, etc.

2. *a.* A flat dressed side of a stone.

b. One of the parallelopipeds of buhr-stone which are confined by hoops and form a millstone.

3. (*Joinery.*) One of the divisions of a work which has sunken portions surrounded by framing. A PANEL (which see).

4. (*Machinery.*) The divisions or sides of a nut or bolt-head; as, a *six-paned* nut, *i. e.* a hexagonal nut. *Panel* is an allied word.

The pointed or edged end of a hammer-head. Properly PEEN (which see).

5. (*Hydraulic Engineering.*) One of the divisions of a plat between a feeder and an outlet drain.

6. (*Diamond-cutting.*) One of the sides of the *table* or upper surface of a *brilliant-cut* diamond. The table has eight panes. See BRILLIANT.

Pan′ei-con′o-graph. See PANICOGRAPH.

Pan′el. 1. The sunken portion of a *door*, wainscoting, head-board of a bedstead, etc. Its edges are mortised into the surrounding frame, whose uprights, in a door, are termed *stiles*, and horizontal pieces, *rails.* Middle vertical pieces between double panels are *munions.*

Carriage panels are, in the United States, usually of poplar strengthened by strong canvas fastened thereto by glue.

2. A compartment in a sunken ceiling, soffit, bay, or wainscot.

3. A face of a hewn stone.

4. (*Painting.*) A thin board on which a painting is made.

5. A square. See PANE.

6. (*Bookbinding.*) *a.* A depressed part of the sides within a relatively elevated bordering portion.

b. A space on the back between bands.

7. (*Mining.*) *a.* A heap of dressed ore ready for sale.

b. A system of coal-mining in which the projected *winning* is divided into large square allotments divided by massive walls of coal, instead of placing the whole working in one undivided arrangement. The *pillars* are left very large, the *rooms* small; the *pillars* are worked out, props being substituted; these are knocked out and the *goaf* filled up by the caving down of the ceiling.

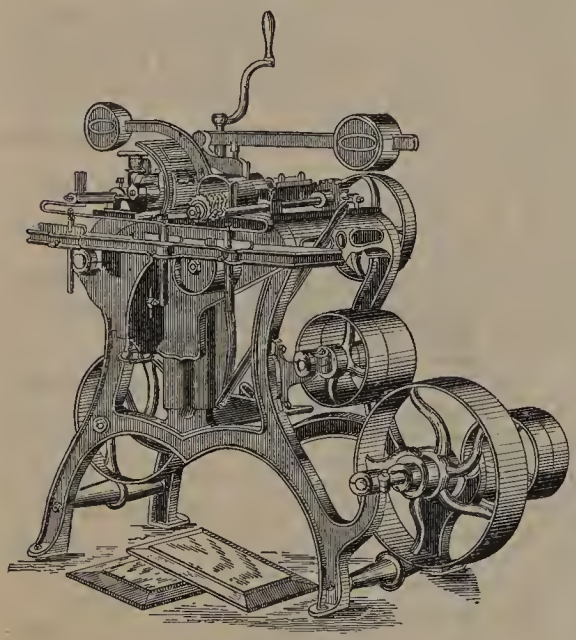
8. A pad or packing beneath a saddle to protect

the horse's back from contact with the tree. It is usually made of basil stuffed with wool, doe-hair, or horse-hair, lined or quilted with woolen serge, or at times, for hot climates, with holland, and for race-saddles with silk or other soft material. The principal difficulty with panels is to keep them of their original softness.

Pan'el-plane. (*Wood-working.*) A long stocked plane having a handle or *toat*. The stock is somewhat deeper than that of the jack-plane.

Pan'el-rais'er. (*Wood-working.*) One employed to rabbet away the angle and a part of the surface of a board, in order to give it a sunken margin, leaving a *raised panel*. The cutters have such a contour as to give the required molding to the edge of the raised portion. The example is known as a *double-head panel-raiser*, working upon two edges of the board at once, at a gaged distance apart. A couple

Fig. 3502.



Fay's Panel-Raiser.

of the worked panels are shown on the floor below the machine.

Pan'el-saw. A hand-saw for paneling. It has six teeth to the inch.

Pan-ic'o-graph. A mode of obtaining printing-plates direct from a subject or transfer by applying it to the face of a plate of zinc, and building up a printing surface in relief corresponding to the design transferred. The processes are: —

1. Place on the polished plate the design in transfer ink; dust rosin on the ink, which gives it hardness and substance; then eat in the uncovered surface.

2. Coat the zinc with a non-conducting surface; draw or write the design with a conducting ink; throw down copper on the lines in the electroplating bath; remove the non-conducting coat and eat down the zinc surface by making the plate the positive electrode of the battery.

3. Coat the plate with whiting and etch with a point; cover with varnish, which will adhere to the uncovered metal; wash off the whiting and bite in the parts of the plate not covered by the varnish.

Panne. (*Fabric.*) Worsted plush of French manufacture.

Pan'nier. 1. (*Hydraulic Engineering.*) A basket or gabion of wicker-work containing gravel or earth, and used in forming a basis for earthy material in the construction of dikes or banks to exclude water or to resist its eroding action upon its natural banks.

2. Baskets — usually in pairs — slung over the back of an animal of burden to carry a load. The ancient Egyptian paintings show asses with panniers full of children.

Pan-nus-co'ri-um. A kind of leather cloth used for making boot uppers.

Pan-o-ra'ma. A painting of a complete scene, such as that of London as viewed from a central point, by Barker, from the summit of St. Paul's, or made continuous upon an unrolling canvas, as if the spectator were passing the particular spots consecutively.

In a *diorama* the scenes are isolated and viewed through a large opening, the surrounding proscenium affording a frame for the picture or succession of pictures. This mode of pictorial representation was invented by Daguerre and Bouton. It has great facilities for scenic and illuminative accessories, by opaque and transparent painting, screens, shutters, reflectors, etc.

A *cyclorama*, as its name indicates, is, or should be, a circular view.

The invention of the panorama is due to Barker, a portrait-painter of Edinburgh, who obtained a patent for his invention in 1787. His panorama of Edinburgh was painted in 1789. In 1792 he exhibited his panorama of London. Fulton introduced the art into France, 1799. In 1821, during the absence for repairs of the cross of St. Paul's, Barker erected an observatory at that giddy hight, and during the summer completed his sketches on 280 sheets of drawing-paper, covering 1,680 square feet. The painting made from his drawing adorned the interior of the dome of the Athenæum, Regent's Park, London.

The panorama of the Mississippi was made in 1840 by the skill and patience of the painter Banvard, who floated down the river and took the sketches of prominent points and expressive features of the river-banks. It gave rise to a host of similar productions: oceans and river routes, pilgrims' progresses, paradises lost, funerals of Napoleon, moral, immoral, and temperance serials, trades, arts, politics, overland routes to India, emigration to Australia and New Zealand, and, to cap the climax, a cyclorama of the great Lisbon earthquake, which happened about one hundred years previously.

Pan-o-ram'ic Cam'e-ra. (*Photography.*) One in which pictures may be taken on one flat plate, including an angle of 90°, more or less, as required, without introducing defects due to oblique pencils of light. Invented by Sutton. The lens-tube is turned about its axis and directed in succession to the different portions of the field, the dark slide moves with it and presents the proper portion of the sensitized plate opposite to the lens.

Pan'o-type. (*Photography.*) A name given to collodion pictures.

Pan'ste-re-o-ra'ma. A model of a town or country in wood, papier-maché, cork, etc., in which the objects are shown in the proportional relief.

Pan-tel'e-graph. An instrument invented by the Abbé Casselli, for transmitting autographic messages and portraits.

The essential features of the invention are a line connecting a pair of pendulums which have isochronous vibrations. The pendulum at one end of the line carries an iron point over the portrait or message executed or written in insulating ink on a metallic paper, and the other pendulum at the other end of the line carries an iron pencil over a paper

prepared with a solution of the yellow cyanide of potassium.

The electric circuit is completed where the stylus at the transmitting end crosses the insulating ink, and at a corresponding place on the paper at the delivery end a blue mark is made by the other stylus on the prepared paper. See AUTOGRAPHIC TELEGRAPH.

Bonelli's telegraph is of somewhat similar character. See Deschanel's "Natural Philosophy," Part III. pp. 730 - 733.

Pan'tile. A tile curved to an ogee shape, so that the prominent edge of one is covered by the dependent edge of the next. The usual size is $14\frac{1}{2} \times 10$ inches, and they are laid with a 10-inch gage. 170 tiles cover 1 square, i. e. $10 \times 10 = 100$ square feet.

Fig. 3503.

Pantile.

Pan'to-chro-nom'e-ter. An instrument which is a combination of the compass, sun-dial, and universal sun-dial.

A sun-dial is attached to a magnetic needle, suspended in the usual way, in such a manner as to allow for the variation. The divisions of the hours and their fractions are carried on to an additional exterior circle, correspondingly divided; and to a fixed circle around the dial, on which are inscribed the names of a number of places. By this arrangement the gnomon gives the time at the place of observation and also for any other place inscribed upon it.

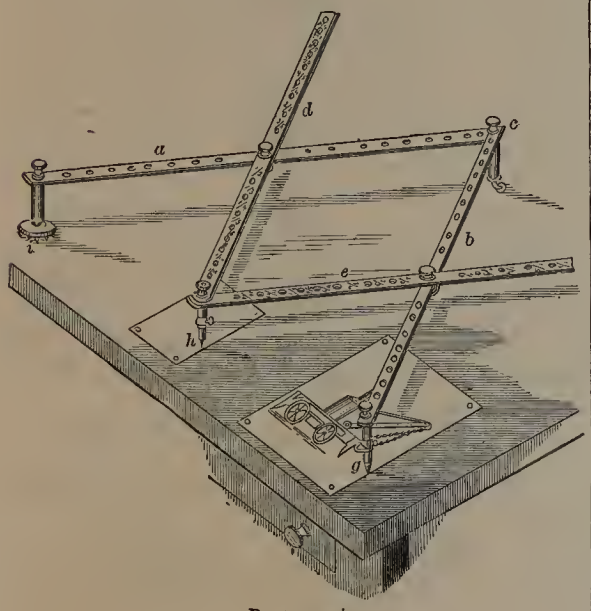
Pan'to-graph. An instrument for copying drawings. Its invention is ascribed to Christopher Scheiner, a Jesuit, 1603. It has since undergone various modifications and improvements.

A device of this kind is alluded to by Pepys.

"This evening Mr. Spong [the inventor] came and first told me of the instrument called a *parallelogram* [pantograph], which I must have one of, showing me his practice thereon, by a map of England." — PEPYS's *Diary*, October 27, 1668.

The pantograph consists of four metallic rules, two of which *a b* are jointed at *e*, and the other two

Fig. 3504.



Pantograph.

d c are jointed over *h*; each rule is perforated with a series of holes, and the two *d c* are provided with thumb-screws by which they may be connected to *a b*, at either of the holes of the series. *g* is a tracer; *h*, a pencil or pricker; and *i* a screw or point which is forced into the drawing board or table to hold the instrument in position.

For use, the rules *d c* are secured to the others by inserting the thumb-screws through the holes marked with the numbers; as, $\frac{3}{4}$, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, etc., corresponding with the scale to which the drawing is to be reduced or enlarged; the point *i* is fixed in a convenient position, and the tracer *g* passed over the outlines of the original; this causes the point *h* to move in a direction parallel to that of the tracer, the extent of its motion being governed by the adjustment above described; and if a pencil-point be employed it describes a figure similar to the original but differing from it in size. In right-line drawings it is more usual to employ a plain needle-point, pricking a sufficient number of points into the paper to serve as a guide to the draftsman, who afterward connects them by lines. The instrument shown in Fig. 3504 is the one used in the reduction of drawings for the illustrations in this work.

The pantograph is used in transferring patterns to copper cylinders for calico-printing. The system was patented by Rigby in England in 1854, and improved in 1857, so that by employing a number of tracers all the similar figures in a pattern may be produced at once.

In this process the pattern to be copied is first drawn on paper which is placed in a camera which throws an enlarged image on a sheet of paper; this is traced on the paper, which is then transferred to a zinc plate, in which the figures are cut with a graver. The plate is then laid on the curved bed of the pantograph machine, on which a varnished roller is mounted; a number of diamond-points corresponding to that of the lateral repetitions in the pattern are brought in contact therewith, and the tracer is successively passed over each part of the enlarged pattern on the zinc plate, causing the diamond-points to describe a series of figures, reduced to the size of the original drawing on the varnished copper cylinder, which are afterward etched in with acid.

The *micropantograph*, for copying on a very minute scale, may be described as a system of connected pantographic levers, the last of which carries a piece of glass on which the original is reduced in a proportion determined by the relation between the lengths of the longer and shorter arms of the series.

The glass rests and moves upon a diamond-point while the point remains stationary. The diamond may be raised or lowered by appropriate mechanism, to regulate the width and depth of the cut or entirely remove it from the glass.

With an instrument of this kind the Lord's Prayer has been written within the space of $\frac{1}{3600}$ of a square inch. In the same ratio the whole of the Old and New Testament would be contained within $\frac{1}{27}$ of a square inch. See MICROPANTOGRAPH.

Pan-tom'e-ter. An instrument for measuring angles for the determination of elevations, distances, etc.

Pa'per. A material made in thin sheets from a pulp of ground rags or other fiber, and used for writing or printing upon or for wrapping. The name is derived from *papyrus*, an Egyptian reed whose stalk furnished for so many centuries the principal material for writing upon and for wrapping, to the nations bordering upon the Mediterranean. In his day, Pliny remarked: —

"All the usages of civilized life depend in a remarkable degree upon the employment of paper. At all events, the remembrance of past events."

This observation, undoubtedly true 1,800 years ago, is much more remarkably so now; indeed, in considering that paper as we now understand it was

entirely unknown to Europe in the time of Pliny, the expression of the great dependence upon what seems to us so fragile and ineffieient a substitute for real paper appears strange.

The Greek name *papuros*, mentioned by Theophrastus, a contemporary of Aristotle and Alexander, was probably the Egyptian name of the reed with a Greek termination. It was also called *biblos* by Homer and Herodotus, whence our term *bible*. The term *volumen*, a seroll, indieates the early form of a book of bark, papyrus, skin, or parehment, as the term *liber* (Latin, a book, or the inner bark of a tree) does the use of the bark itself. Hence also our words *library*, *librarian*, etc.

Pliny indorses the statement of Varro that the discovery of the use of the papyrus was an incident in the victorious expedition of Alexander of Maeedou; this was not correct, but no doubt the expedition contributed to introduce the papyrus to the nations of the West. Egyptian tombs show that it was used many ages before the time of Alexander, and, indeed, long prior to any authentic historieal accounts of Greece; its existence being proven nearly as far back as the stone reeords of Egypt extend, or nearly to the time of Menes himself (2400 B. C.).

It seems to have been early known to the Hebrews. Isaiah refers to the papyrus plant when he says, —

"The paper reeds by the brooks, and everything sown by the brooks, shall wither, be driven away, and be no more."

This prediction of the prophet has been long since fulfilled, and the plant is now comparatively rare.

An aneient Egyptian papyrus on the preparation of medicines, which was found at Thebes by Dr. Ebers, has lately been placed in the Leipsic Library. It is in a good state of preservation, and consists of one hundred and ten columns; written on the back is a double ealendar in eight eolumns. Each column is eight inches wide, and contains twenty-two lines. The writing is from right to left; it is all in black ink, except the beginnings of ehapters, which are in red ink. The characters are distinct, bold, and tasteful, and their form appears to fix the seventeenth century B. C. as the date of the manuscript; the faet that in the ealendar the name of King Ra-ser-ka (Amenophis I.) is mentioned, proves that the papyrus is not posterior to the first half of that century.

The work itself dates from a period more remote than its transcription on papyrus It is known that the most ancient Egyptian writings were works about medicine. Manetho tells us that the Egyptians honored one of their first kings as a physician. This assertion is confirmed, not only by the fragment of papyrus of Brugsh and Chabas, preserved in the Berlin Museum, but also by the present document.

The first chapter of the papyrus treats of the original production of the book, which came from the Temple of On (Heliopolis). Then follow the remedies employed for the cure of various diseases, together with extensive details as to diseases of the eye, remedies against the falling off of the hair, for sores, fevers, the itch, etc. The chapter devoted to the mistress of the house is succeeded by one about the house itself, which insists on the importance of cleanliness, and tells how to banish insects, to exclude them from houses, to prevent serpents from coming out of their holes, to avoid the stings of guats and the bites of fleas, and to disinfect clothing and dwellings. Then there is a treatise on the relations between soul and body, with secret methods of studying the heart and its movement.

The gossiping and agreeable Pliny gives a detailed aceount of the preparation of paper from the Nile reed. This indefatigable man is principally known to us by one only of his voluminous writings, his treatise on "Natural History." This, however, treats on a great multitude of subjeets, including agriculture and the arts and sciences, and affords a very interesting reeord of the state of practical knowledge at that time. He was suffocated by the mephitie vapors at the eruption of Vesuvius, A. D. 79, which he had imprudently approached too nearly, for the purpose of scientific investigation.

It may be remarked, that this eruption of Vesuvius, described with so much animation by Pliny the Younger, did not utterly destroy the cities of Herculaneum and Pompeii, as is popularly supposed. We find them emerging from their ruins in the reign of the Emperor Titus, in the fifth year of whose reign they suffered so much. They yet subsisted in the reign of Hadrian, under the Antonines, and are mentioned as inhabited cities in the chart of Peutinger, which is of the date of Constantine. The eruption of A. D. 471 was probably the most frightful on record; and if we may believe Marcellinus, the ashes of the volcano were vomited over a great portion of Europe, reaching to Constautinople, where a festival was instituted in commemoration of the strange phenomenon. After this, we hear no more of the cities, but the portion of the inhabitants who escaped built or occupied suburbs at Nola in Campania and at Naples. In the latter city, the *Regio Herculanensium*, or *Quarter of the Herculaneans*, an inscription marked on several lapidary monuments, indicates the part devoted to the population driven from the doomed city.

From Pliny we learn that the papyrus plant grew in the marshes of Egypt or in the sluggish waters of the river Nile in pools which did not exceed 3½ feet in depth, forming a gracefully tapering stalk, triangular in cross-section and not over 16 feet (10 eubits) in hight.

The paper made from papyrus was of nine different qualities, varying in size, color, and texture. It was made "by splitting the successive folds of the stalk with a needle into very thin leaves, due care being taken that they should be as broad as possible. That of the first quality is taken from the center of the plant, and so on in regular succession, according to the order of division."

Each quality was known by a different name, as "Augusta," "Liviana," "Hieratica," etc., the latter from the fact that it was reserved for religious books. The "tamotic" and "emporatica" were sold by weight, and used by dealers for wrapping, while the bark was used for making cordage.

All these various kinds were made upon a table moistened with Nile water; a liquid which, when in a muddy state, was supposed to have some of the properties of glue. There is little doubt, however, that this adhesive property was inherent in the plant itself, and in some instances we know that paste was employed. The table being first inclined, the flakes of papyrus were laid upon it lengthwise to such length as the papyrus would admit of, the jagged edges being cut off at either end; after which a cross-layer was placed over it. When this was done, the leaves were pressed close together and then dried in the sun, after which they were united to one another, the best sheets being always taken first, and the inferior added afterward. There were never more than twenty of these sheets to a roll. The width varied according to quality from thirteen to six fingers' breadth.

In making, the leaves were beaten and thinned out with a mallet, and the leaves united by paste. Roughness was subsequently smoothed down with a burnishing tooth or shell, which polished the surface. We may remark that modern microscopical investigation has demonstrated the fact that three instead of two layers of the liber were usually if not universally employed.

As a material for writing upon, the Mexicans used cotton cloth or skins nicely prepared, or a composition of silk and gum, but principally a fabric prepared from the aloe, *Agave americana*, called by the natives *maguey*, which grows freely over the table-land of Mexico. The paper somewhat resembles the Egyptian *papyrus*, and is polished to resemble parchment. It took color and ink excellently, and many specimens remain. It was sometimes rolled up in scrolls; at other times was made up in packs of leaves, with a tablet of wood for the outsides. The leaves were separate.

A species of incombustible paper was made from asbestus in the time of Pliny.

To give an idea of the bulky nature of papyrus manuscripts it may be mentioned that Ovid's Metamorphoses occupied fifteen rolls.

The abundanee of papyrus in Egypt, the chief source of its production, the magnificence of the kings of that country, and the coneourse of learned men who resorted thither, caused it to become the seat of those immense libraries which we read of as having perished in the flames during the siege of Alexandria by Julius Cæsar, B. C. 47, under Theodosius about A. D. 388, and finally under Omar the Saraeen about A. D. 639. During this interval, however, the Alexandrian library had been increased

THE PAPYRUS-PLANT OF THE NILE.

PLATE XXXVI.

See page 1004.

by the addition of that of Eumenes, king of Pergamos, which had been presented by Marc Antony to Cleopatra. The volumes composing this latter were written largely on parchment, and, according to the old story, this material was invented or discovered by Eumenes, about 200 B. C., in consequence of a prohibition laid on the exportation of papyrus from Egypt, due to the fact that one of the Ptolemies wished to have no rivals in the matter of libraries, and proposed by this means to prevent Eumenes from proceeding with his proposed collection. The latter, however, it appears, was not to be thus deterred from his favorite project, and contrived a method of preparing skins of animals which fully answered his intended purpose.

As skins for records had been known for so many ages, among the Hebrews for instance, we may fairly presume that the invention of Eumenes merely related to a peculiar mode of dressing. It may be conjectured, perhaps, that previous to the time of this king writing upon skins had been done with paint, and not with ink. Paint consists of a pigment ground in oil, and ink is a dye dissolved in water. The former does not flow freely, and cannot well be used with a pen, but requires an implement of the brush kind for its proper application. Neither, however, can well be applied to skins which still retain a large portion of their fatty matters; an ink can hardly be used at all for forming legible characters on skins in this condition, though a paint, to a certain extent, may.

Parchment, in addition to having been selected and reduced to a regular thickness, has been specially treated with detergents, and a proper surface raised by pumice-stone, so that it is adapted to receive and retain ink. Papyrus being the ordinary material for writing, and being eminently calculated to receive the aqueous colored solution called ink, it was the object of Eumenes to render the skins of animals suitable for the reception of such a fluid, and avoid the necessity of going back to the use of paints. The name of Crates of Mallos is honorably associated with that of Eumenes in the enterprise, if not the invention.

All public documents under Charlemagne were written on parchment except by the Popes, who used papyrus till the twelfth century. Papyrus continued to be used for epistolary correspondence till the introduction of paper by the Saracens.

The bull of Pope Agapetus, dated 951, was written on papyrus, and perished in the burning by the French communists of the library of the Louvre, May 24–25, 1871.

Many ages must have passed in Egypt before the ingenious mode of obtaining paper from papyrus was devised. At this distant period we may assume that Pliny's remarks were true of the Nile land, as in that writer's own age they were true of Asia and parts of Europe.

"At first men wrote upon leaves and afterward upon the bark or rind of trees." Reference has already been made to the terms *volumen* and *liber*, and the origin of another set of words is no less apparent. The modern word *page* is from the Latin word *paginæ*, flat leaves; and the word *leaves* is also applied, being the translated form of *paginæ*, as *page* is the derived word. *Folio* is also from *folium* (Latin), a leaf, indicating the material so commonly used. Writing on palm-leaves was practiced among all peoples where that tree flourished; the Singhalese and other East-Indian nations retain it to the present day. Oblong pieces of the green leaf are trimmed uniformly, so as to be strung together to form a book, — a shaky and insecure binding, but one quite common in museums. The writing is scratched through the external cellular matter of the leaf, which shrinks away from the incision, into which a black pigment is sometimes rubbed.

Many other materials have been used by savage and semi-civilized nations for records more or less enduring. Under the article PEN may be found some references to pictured and inscribed rocks, to writings on tablets, skins, stones, slabs of clay, bones, shells, linen, metallic plates, and ivory. See PEN.

Close at home we have an excellent substitute in an emergency, birch-bark, used by the northern tribes of Indians. In Polynesia and Oceanica, as well as in China and Japan, the *Morus papyrifera*, or paper-mulberry, yields an inner bark which is of great value. In Java and Sumatra it is the ordinary material for writing upon. Its use as a garment is perhaps most extensive among the Feejees.

Among these ingenious cannibals the *tappa* cloth, as it is termed, is made by removing the bark from the tree in strips six feet long and three inches wide. These are soaked and then beaten on a table with flat grooved mallets, until the strip is extended into a sheet as wide as it is long. This is then flattened with a smooth mallet, and pieces may be united by beating their edges together.

In the due course of the ages, papyrus and parchment having rendered an elastic pen (*calamus*, a reed) and a fluid ink the most convenient materials for writing, we find they long maintained an almost uninterrupted sway, the variations being in the use of waxed tablets, leaden plates, and waxed linen, as explained under PEN.

The great change occurred when *true paper* was made of *rags or other vegetable fiber, reduced to a pulp, gathered into a sheet, felted in setting, and dried.*

Human invention had, in this case, been anticipated by the wasp, which insect may be considered as a professional paper-maker, devoting a large portion of her time and energies to the production of this fabric, of which she builds her nest. For this purpose she seeks dry wood,—fence-rails and weather-beaten boards are a favorite source of supply, — which she saws or rasps by mastication, mixes with a natural size exuded for the purpose, works into a paste, and spreads into sheets in a manner truly marvelous Any one who has pelted hornets' nests with stones from a safe distance, or given them a passing blow with a stick as they hang from a limb in the orchard, will be led to admire the strength which a pulp of chewed wood and albumen may be capable of exhibiting.

The structure is generally a prolonged irregular spheroid, wonderfully light, and is bound by repeated layers and bands of paper to the bough from which it is suspended. The material resists rain, partly from the shape, the roof being rounded; partly from the fact that the successive layers overlap, or, in other words, that the dome is *shingled;* and partly, we presume, from its being rendered semi-waterproof by the size in its composition

The mode of procedure is interesting. Having finished the ceiling, the hornet begins to build the first terrace of her city. The females and neuters do most of the work among all insects of this class. The charges and distractions of maternity are, however, in most cases removed from the workers whose gender is suppressed, though the mother hornet, unlike the queen bee, is eminently industrious. To resume: the upper terrace of cells in the interior of the structure is of a general circular shape, and is suspended from the ceiling of the dome by a stalk and stays of the same material which composes the body of the nest. The cells in the terrace are hexagonal in form, and have their mouths downward. These are not appropriated to honey, as the insects do not lay up provisions, but they are devoted to the rearing of the young. A set of cells being completed and eggs laid therein, the work is intermitted, and the mother's time devoted to supplying food for the grubs, which soon require her care. When, in a few weeks, they are able to go abroad themselves, they help extend the quarters, and a new terrace is constructed, supported by stems from that above. The community of paper-makers may amount to 30,000 in a single season, according to Reaumur.

The Chinese, at the time of Kung-fu-tze (about 600 B. C.), wrote with a style upon the liber of trees, as their records state. Paper was used, perhaps invented, in that country in the reign of Wan-te, 179–

156 B. C. That made previous to the Christian era is supposed to have been of silk. Engrossing on cloth and silken stuffs had been practiced for many centuries previously. The Chinese silk paper is stated by Martini to have been invented in China about 120 B. C., and to have found its way into Persia and Arabia about A. D. 620.

The bark-paper of China is made in the following manner: The small branches of a species of tree resembling the mulberry (*Broussonesia*) are boiled in lye to loosen the bark; this is then macerated in water for several days, the outer part scraped off, and the inner part boiled and agitated in lye until it separates into fibers. It is then washed in a pan or sieve and worked by the hands into a pulp, which is afterward spread on a table and beaten fine with a mallet. The pulp is next placed in a tub containing an infusion of rice and a root called *oreni*, and thoroughly stirred to mix the materials. The sheets are formed by dipping a mold, made of strips of bulrushes confined in a frame, into the vat containing the pulp, and are, after molding, laid one on another with strips of reed between. A board and weights are laid on the pile to express the water, and they are then separated and dried in the sun. This paper is so delicate as to bear writing on one side only. When it is desired to write on two sides a couple of sheets are pasted together back to back.

The Chinese paper of bamboo fiber is likewise very ancient, and is made by pulping and gathering the pulp in films.

The Chinese *rice-paper*, so called, is prepared from the inner portion of the stems of a hardy leguminous plant that grows plentifully about the lakes near Calcutta and also in the island of Formosa, whence the Chinese import it in large quantities. The stems of the plant being cut into the proper lengths for the sheets, the pith is cut spirally into a thin slice, then flattened, pressed, and dried. It thus resembles very closely the papyrus in the mode of manufacture.

It is said that in Japan, previous to the year A. D. 280, silken stuff, with a facing of linen, was used for writing upon. Subsequently paper was imported from the Corea, and about 610 A. D. the *Broussonesia papyrifera* (paper mulberry) was introduced, from which the greater part of the paper now used in that country is made.

This is manufactured by boiling the stalks of the plant, causing the bark to separate. The outer portion of this is converted into paper of an inferior quality, while the inner skin is treated by farther boiling, washed, and pounded by beating with clubs on a wooden table. The pulp thus formed is made into balls, from which portions are broken off as required and mixed with a paste made from the root of the *troro*, a sort of shrub. The mixture, thoroughly incorporated and of proper consistency, is poured into a mold consisting of an inner and outer frame, the former having a false bottom. The sheet thus formed is turned out of the mold and dried on boards. The whole process and its manipulations bear a striking analogy to those employed in making hand-laid paper in the European way, as will be subsequently described. The process differs in some respects from the Chinese plan described above.

The conquests of the Saracens cut off the supply of papyrus to Europe, and that energetic people made amends by introducing true paper.

They are supposed, by their conquests in Bucharia about the year 704, to have acquired the art of making cotton paper, and substituted it for the silk of the far East and the papyrus of the South. In the eighth century the Saracens conquered Spain, and through that peninsula the art of making paper reached the rest of Europe. In the same century, the art is said to have been introduced into Constantinople from the East. Paper was made by the Saracens in Spain from flax, and afterward from cotton. Some time previous to this, however, a cotton paper, made in Damascus and designated as *Charta damascena*, had been known in Europe.

An Arabian author of the thirteenth century states that cotton paper was invented at Mecca by one Joseph Amru, about the year of the Hegira 88, that is, A. D. 706. Another Arabian authority states that a paper manufactory was found at Samarcand, in Bucharia, when the Arabs conquered that country in the year of the Hegira 85.

The oldest manuscript written on cotton paper in England is in the Bodleian collection of the British Museum, and bears date 1049. The most ancient manuscript on the same material in the Library of Paris is dated 1050. In 1085 A. D., the Christian successors of the Spanish Saracens made paper of rags instead of raw cotton, which is recognized by its yellowness and brittleness. A very early specimen of *linen* paper is found in a manuscript bearing the date of 1100 A. D.; though some twelve years afterward we find Roger, king of Sicily, granting a charter to some paper-makers who were then established on that island. The paper made by them was, however, probably of cotton, which was then extensively grown in Sicily.

In 1151, we learn from an Arabian author that paper of a superior quality was manufactured at Xativa, in Spain, the Christian Spaniards having improved upon the processes of the Moors, from whom they learned the art, by stamping the raw material, raw cotton and rags, by the aid of a water-mill.

In 1170, Eustathius, the commentator on Homer, remarks that papyrus had fallen into disuse.

In 1178, we find several specimens of flax paper in Spain, and in the University of Riteln in Germany a document is preserved, signed by Adolphus, Count of Schaumberg, made from linen rags. A letter from Joinville to Louis X. of France, dated 1315, and written on paper made from rags, is yet extant. After this period the notices of paper and of paper-making become frequent.

Linen paper is found in documents of 1241 (edict of Emperor Fred. II.) and 1300. The Arabian physician Abdollatiph, who visited Egypt in 1200, says that the mummy-cloths (*linen*) were habitually used to make wrapping-paper for the shop-keepers. The linen paper of the thirteenth century had the water-lines and water-mark. One specimen had a tower.

The earliest manuscript on linen paper known to be English bears date fourteenth year of Edward III., 1320. The first water-mark, a ram's head, is found in a book of accounts belonging to an official of Bordeaux, which was then subject to England, dated 1330. It has been claimed that linen paper was made in England as early as 1330, though it is supposed that no linen paper was made in Italy previous to 1367.

In 1390, Ulman Strother established a paper-mill at Nuremberg in Bavaria, operated by two rollers, which set in motion eighteen stampers. This indicates the process of pulping the fiber by beating, which continued in use for nearly four centuries. This was the first paper-mill known to have been established in Germany, and is said to have been the first in Europe for manufacturing paper from linen rags.

In 1498, an entry appears among the privy expenses of Henry VII. for "a reward given to the paper-mill," 16*s.* 8*d.* This is probably the paper-mill mentioned by Wynkin de Worde, the father of English typography. It was located at Hartford, and the water-mark he employed was a star within a double circle. The jug or pot was a favorite water-mark about the middle of the fifteenth century, preceding the fool's cap, which has given its name to the largest size of writing-paper now in common use. About 1540, it appears that Henry VIII. of England, to show his animosity to the Pope, with whom he had then quarreled, used for his private correspondence a

paper of which the water-mark was a hog with a miter.

The barbarous law of England imposing a duty on paper appears to have had a precedent in France under Charles IX., the author of the St. Bartholomew massacre, who, in 1565, levied an impost on that article, which was soon abolished at the instigation of the University of Paris.

It appears that wall-paper, as a substitute for tapestry or hangings, began to come into vogue about the year 1640.

It does not appear that the paper manufacture flourished in England until after the revolution of 1688, as we find that in 1663 England imported from Holland alone paper to the amount of £ 100,000.

This hardly preceded the establishment of paper manufactories in America, as we find that William Rittinghüysen, anglicized Rittenhouse, — a name afterward memorable in the history of American science, — a native of Holland, in conjunction with old William Bradford, one of the earliest of American printers, who will be doubtless remembered by those who have read Franklin's Autobiography, established a paper-mill at Roxborough, near Philadelphia, on a stream still called Paper-mill Run, a tributary of the Wissahickon. The raw material for its supply was derived from linen rags, the produce of the old clothes of the vicinity, and native rags long continued to be the chief source from which American paper was derived. In 1710 another paper-mill — the second in America — was erected at Crefeld, now forming part of Germantown, by William De Wees, a connection of the Rittenhouse family. In 1724, William Bradford endeavored to induce the New York legislative council to grant him a monopoly for the exclusive manufacture of paper for fifteen years, but was unsuccessful.

Reaumur in 1719 suggested, from the examination of wasps' nests, that a paper might be manufactured from wood, but we do not find this idea farther acted upon until a later period, when inventors seem to have exhausted their ingenuity, regardless of expense, in the selection of materials from which paper might be manufactured.

Paper, in fact, cannot, as a general thing, be economically made from fibrous material which has not already previously been manufactured. That is to say, so long as the prices of vegetable fibrous substances, as cotton, flax, etc., remain the same, it will be much more economical to use them for the purpose of reducing into pulp for paper-making after they have already undergone the process of manufacture into clothing, than to take them in their raw state, when they may still be subservient to the economic physical wants of man.

Since Reaumur first suggested wood as a substance from which paper could be made, the articles proposed for that purpose have been almost innumerable; in fact, anything having a fibrous texture *may* be used, and the question resolves itself into one of economy. See PULP-BOILER.

Koops in 1800 published a work on paper, which was printed on paper made of straw, with an appendix on paper made of wood. A second edition was published in 1801, upon paper re-made from old printed and written paper. In 1835, Piette published a work on the subject of "Paper from Straw," etc., giving 160 specimens.

In 1765, Schaeffer, of Ratisbon, printed a book on sixty varieties of paper made from as many different materials; a copy is now in the Smithsonian Institute Library.

In 1786, the Marquis de Vilette published in London a small book, printed on paper made from marsh mallow; at the end are leaves of paper manufactured at Bruges from twenty different plants, such as nettles, hops, reeds, etc.

The following is a list of materials (numbering in all 402) from which paper has been made or proposed to be made, with references to the authorities from which the information has been derived.

PAPER-MAKING MATERIALS.

The following materials, among others, have been used or suggested for paper-making. The authorities are cited as follows: —

a refers to English patents.
b refers to Examiner's Digest, Patent Office.
c refers to Munsell on Paper-making.
d refers to Schaeffer on Paper.
e refers to "Central Blatt," "Papierfabrikation," Dresden.
f refers to "Journal des Fabricants de Papier," Paris.
g refers to "Die Fabrication des Papieres," Piette, Cöln.

Abelmoschus esculentus, *e*, xiv. 17.
Abutilon avicennæ, *b*.
Acacia, *a*; *f*, xii. 97, xiv. 354, xvi. 117.
Agave, *a*; *d*.
Alfa fiber, *c*.
Alga marina, *b*.
Algæ (fresh-water), *b*.
Aloe fiber, *d*.
Aloes, *a*; *d*; *e*, i. 107, iii. 520, vi 210, x. 119, xiii. 117, 126, xiv. 17, xvii. 111; *g*, ii. 114; *f*, xiv 354.
Alsimastrum, *a*.
Althea, *e*, xiii. 117.
Ammonum, *a*.
Anacharsis, *a*.
Ananas (see PINEAPPLE).
Animal exeremeut, *a*.
Animal substanees, *c*.
Anonaeeæ, *a*.
Apocineæ, *a*.
Aporentype, *c*.
Arroehe, *c*.
Artemisia bark, *d*.
Artemisia wood, *d*.
Artiehoke, *a*.
Artiplex, *d*.
Artoearpeæ, *a*.
Arundinaria macrosperma, *b*; *c*.
Asbestus, *a*; *b*; *d*; *g*, ii. 149; *f*, viii. 296. See also page 167, supra.
Aselepiadiæ, *a*.
Asclepias, *d*; *f*, xi. 29.
Asparagus, *a*.
Aspen, *c*; *d*; *e*, vii. 81, xvi. 184.
Asphodel, *a*.
Bagasse, *a*.
Bagging, *c*.
Bamboo, *a*; *b*; *e*, xiv. 17, xvi. 71; *f*, xv. 187.
Banana, *a*; *e*, i. 107, iii. 520, vi. 210, xvii. 171.
Bark of wood (various), *e*, v. 557; *g*, 31, 32, 33.
Barks of resinous woods, *b*.
Barley straw, *c*.
Basswood, *c*.
Bean leaves, *d*.
Bean vines, *a*; *e*, xiii 117.
Beans, *b*.
Beeehwood, *d*.
Beet, *a*; *e*, iii 519, ix. 181, 186.
Beet and mangold-wurzel root, *b*.
Begonaceæ, *a*.
Berries, *a*.
Birch, *a*; *e*, xiii. 184, xviii. 9.
Blaekberries, *a*.
Blue eabbage stalks, *d*.
Blue grass, *c*.
Boehmeria, *a*; *e*, xiii. 126.
Bombax, *a*.
Braeken, *c*.
Bran, *a*; *c*.
Brazil wood, *d*.
Brazilian grass, *c*.
Brewery refuse, *a*.
Bromeliaceæ, *a*; *e*, v. 142, vi. 210. xvii. 171.
Broom, *a*; *e*, v. 94, vi. 210, xiii. 117, xv. 113.
Broom corn, *b*.
Broom, swamp, *b*.
Broussonesia, *a*; *e*, vi. 234, xvii 171.
Bryona, *a*.
Buckwheat, *a*.
Bulrushes, *a*.
Burdoek, *a*; *d*.
Cabbage, *b*.
Cabbage stumps, *c*.
Caetus, *a*.
Canes, *a*; *b*.
Cardanus metans, *c*.
Cat-tail down and leaves, *d*.
Cecrops draeena, *a*.
Cedar wood, *b*.
Cenodrulı, *a*.
Chaff, *f*, iii. 137, 148, 164, 184, iv. 3, 21, 33, 51, 66, 82, 164, v. 28, 117, 132, 189, 204, 221, vi. 87, 106, ix. 67, xii. 121.
China grass (*Rhea*), *e*, v. 142, vi. 222, xiii. 126, xvii. 171, xix 134; *f*, x. 369, xiv. 354, xvi. 117.
Cissus family, *a*.
Clematis bark, *d*.
Clematis wood, *d*.
Clematite, *c*.
Clover, *a*.
Coir, *e*, xiii. 126, xiv. 17.
Coltsfoot, *c*.
Compositeæ, *a*.
Conferva, *c*; *d*.
Coniferæ leaves, *a*.
Convolvulaeeæ, *a*.
Coral moss, *d*.
Cordage, *a*.
Cork, *a*; *e*, xvii. 54.
Corn eobs, *b*; *c*.
Corn husks, *a*; *d*.
Corn leaves, *c*.
Corn stalks, *b*; *c*.
Coton du peuplier, *c*.
Cotton, *a*.
Cotton plant, *b*.
Cotton seed, *b*.
Cotton stalks, *b*.
Couehgrass, *a*.
Crueiferæ, *a*.
Cryptogams, *a*.
Cucumbers, *a*.
Cucurbitaecæ, *a*.
Cupheæ, *a*.
Cyprian asbestus, *d*.
Daphne, *e*, iv. 673, vi. 210, 247, xiv. 17, xvii. 171, xviii. 5.
Deeayed wood, *c*.
Diss, *g*, ii. 115.
Dog's grass, *a*.
Duuhee (*Sesbanea aculeata*), *e*, xiii. 126.
Dury, *e*, i. 248.
Dust, *a*.
Dwarf palm, *c*; *e*, xi. 210, xvii. 171.
Dyewoods (spent), *a*.
Earth moss, *d*.
Ejoo, *e*, xiv. 17; *f*, xii. 19, 146.
Elder, *a*.
Elm, *c*.
Erieaceæ rushes, *a*.
Erigerone, *c*.

Erytoxylon guttafereæ, *a*.
Esparte, *c*.
Espartero, *c*.
Esparto grass, *b*; *c*; *e*, xiv. 19, xv. 69, 108, 121, 138; *f*, vi. 132, 150, 166, 185, vii. 5, 21, xiv. 178, 296; *g*, ii. 24, 116, xvi. 187.
Euphorbiaceæ, *a*.
Excrement of herb-eating animals, *a*; *b*; *f*, iii. 59, viii. 54.
Fcnequen (Sisul hemp, Sosquil), *e*, vi. 247, xvii. 171.
Ferns, *a*; *f*, iii. 100, xiii. 117; *g*, ii. 80, 81, 84.
Fibrilla, *e*, xiii. 117.
Fir, *c*.
Flags, *a*.
Flax, *a*; *e*, vi. 236, xiii. 117, xiv. 17; *f*, xiv. 354, xvi. 17, 119.
Flax, New Zealand, xiii. 126, xvi. 17, 282, xvii. 171.
Flax, hemp, etc., *b*.
Floss silk, *c*.
Fourdrini, *a*.
Frog spittle, *c*.
Furze, *a*.
Galeg officinalis, *b*.
Galega orientalis, *b*.
Galingale, *a*.
Genista, *a*; *d*.
Genista after extracting dye, *d*.
Geld (*Marsdenia tenacissima*), *e*, xiii. 126.
Gnaphalium, *c*.
Gramina, *a*.
Gramineæ, *a*.
Grape-vine, inner and outer bark, *d*.
Grape-vines, *c*, xiii. 117.
Grasses, *a*; *e*, xiii. 117; *f*, vii. 117
Grass, Spanish, *b*.
Grass, Tule, *b*.
Gutta-percha, *a*.
Gunny, *e*, xvii. 4.
Gun cotton, *f*, iv. 90.
Hair, *a*.
Hay, *a*; *g*, ii. 4.
Heather, *a*; *e*, xiii 117.
Hemp, *a*; *d*; *e*, vi. 222, xiii. 119, xvii. 171; *f*, xiv. 354, xvi. 17, 119.
Hemp, flax, etc., *b*.
Hemp, jute, dressed, *b*.
Hibiscus esculentus, *b*; *c*; *e*, vi. 249, 283, viii. 126, xiv. 19, xvii. 171.
Hides, *c*.
Hollyhock, *c*.
Hop bark, *d*.
Hop vines, *a*; *d*; *e*, vii. 77, xiii. 117, xvii. 171.
Hornet's nest, *c*.
Horse-chestnut leaves, *d*.
Horse-dung, *a*.
Horse-radish, *a*.
Immortelle (cudweed, *Gnaphalium*), *e*, vi. 248.
Indian-corn husks, *d*.
Iris, *a*.
Ivory shavings, *b*; *c*.
Indigo, *e*, xiii 117.
Jucca (*Yucca*), *e*, xiii. 126.
Juncaceæ, *a*.
Juniper, *a*.
Jute, *a*; *e*, vi 234, xiv. 17, xvii. 171; *f*, xiv. 17, 354; *g*, ii. 129.
Kaolin, *f*, i 4, 12, v. 14, 84, 190, vi. 21, ix. 54.
Libitaæ, *a*.
Lace from aloe fiber, *d*
Leather, *b*; *e*, ii. 302; *f*, i. 133, 136.
Leather cuttings, *a*
Leaves, *c*; *e*, vi. 319; *f*, i. 165; *g*, ii. 64.
Leaves of trees, *b*.
Leaves of trees, withered, *c*.
Lecistera formosa, *a*.
Leguminous plants, *a*.
Lentils, *e*, v. 160.
Liliaceæ, *a*.
Lily of the valley, *c*.
Lily of the valley leaves, *d*.
Lily root, *a*.
Lime, *c*.
Linden, *c*; *c*, xviii 9.
Linden leaves, *d*.
Linen, *a*.
Liquorice wood, *c*.
Liquorice root, *e*, ix. 173.
Long moss, *e*, vi. 249.
Lucerne, *a*; *f*, xi. 361, 430.
Lucipodium equisetum, *a*.
Lychuophora, *a*.
Madder, *a*.
Maize, *a*; *e*, ix. 184, x. 358, xi 10, xiii. 117, xiv. 33, xv. 31, 49, xvii. 171.
Maize husks, *b*.
Mallow, *d*; *e*, xiii. 117.
Malpighiaceæ, *a*.
Malva, *a*.
Malvaceæ, *a*.
Mandioca, *a*.
Mangel-wurzel, *a*.
Manila, *a*; *b*.
Manispernum, *a*.
Manure, *c*.
Maple, *a*.
Marzi, *a*.
Masse-d'eau, *c*.
Medichey, *a*.
Melastomaceæ, *a*.
Mineral fiber, *b*.
Moorva, *e*, xiii. 126.
Morus bark, *a*.
Mosses, *a*; *d*; *c*, xvii. 171.
Mothwort, *c*.
Mudar (*Calotropis gigantea*), *e*, xiii. 126, xviii. 5.
Mulberry, *a*; *e*, vi. 234, xiii. 117; *f*, xii 97, 167.
Mulberry inner bark, *d*.
Mulberry-trees, *b*; *f*, viii. 262.
Mulberry wood, *d*.
Mummy cloth, *c*.
Musaceæ, *a*; *e*, vi. 247, xiii. 126, xvii 171
Muscovy mats, *c*.
Mustard, *a*.
Mya grass, *a*.
Myrtaceæ, *a*.
Nettle bark, *d*.
Nettle wood, *d*.
Nettles, *a*; *e*, vi. 210, 234, xiii. 117; *g*, ii. 21.
Oak, *c*.
Oakum, *c*.
Okra (*Hibiscus esculentus*), *b*.
Orache, *d*.
Osier, *a*.
Onocarpus, batava, *e*, xiv. 17.
Palm, dwarf, *c*.
Palm leaves, *a*.
Palm, palmetto, etc., *b*; *e*, xiii 117, xiv. 17; *f*, xiv. 296; *g*, ii. 113
Palmetto and chamœrops (palmetto cabbage), *b*.
Palygaleæ, *a*.
Pampas grass, *a*.
Panax, *a*.
Pandanus, *a*.
Pappus, *c*.
Papyrus, *a*; *f*, xv. 162.
Pasteboard scraps, *c*.
Peas, *b*.
Pea stalks, *a*; *e*, xiii 117.
Peat, *a*; *b*; *d*
Pederia fœtida, *e*, xiii. 126.
Phormium, *a*.
Phormium terrax, *a*.
Pine cones, *d*; *e*, xiv. 7, xvii 171.
Pine shavings, *c*.
Pine-tree, inner bark of, *b*.
Pineapple leaves, *a*; *e*, xiii. 117, 126.
Pisang, *e*, xvii. 171; *g*, ii. 125.
Pita, *e*, v. 142, vi 210, xiv. 17, xvii. 171.
Plane-tree (buttonwood), *e*, vi. 247
Plantain, *c*; *e*, vi. 210, 222, viii. 142, xvii. 171.
Plantain cocoa, *a*.
Plantain-tree (*Musa sapientum* and *paradisiaca*), *b*.
Pollen of plants, *c*.
Poplar, *a*; *e*, xviii. 9.
Poplar down, *d*.
Poppy, *g*, ii. 36.
Potatoes, *d*, ix. 126, 173, 182, xiii. 117.
Potato skins, *b*; *d*.
Potato-vines, *b*.
Pourretia plantanifolia, *b*.
Printed waste, *c*.
Pteris (brake), *e*, ii. 52, 68, 84, 115, iii. 6, 54.
Pulps, *a*.
Pulungor, *e*, xiii. 126.
Rags, *a*.
Ramie, *e*, viii., vi. 210.
Raspberry, *a*.
Reed, *d*.
Reeds, *a*.
Rhamneæ, *a*.
Rhubarb, *a*.
Rice plant (*Oryza*), *b*.
Rice, stalks of the wild, *b*.
Rice straw, *a*.
Ricinus, *a*.
Roots, *a*.
Roots of grasses, *f*, i. 182, ii. 5, 19, 33.
Rope, *a*.
Rosaceæ, *a*.
Rose mallow (*Hibiscus*), *a*.
Rubiaceæ, *a*
Rue, *c*, xiii. 117
Rushes, *a*; *e*, xiii. 117, xiv. 17, xvii. 171; *f*, xv. 289.
Rutaceæ, *a*.
Rye grass, *a*.
Sacks, old, *c*.
Sago, *b*.
Satin, *c*.
Sawdust, *a*; *b*; *d*.
Scotch ferus, *c*.
Sea mallow, *a*.
Sea grass, *e*, vi. 210, xvii. 171.
Sea weed, *a*; *b*.
Secrate, *a*.
Sedge (auticle), *b*; *e*, vi 210.
Seed down of thistles, *d*.
Seratula crvansis, *c*.
Shavings, *d*.
Shavings, wood, *b*.
Shingles, old, *d*.
Sida, *a*; *e*, xiii. 126.
Silk, *a*; *g*, ii. 135.
Silk plant (*Asclepias*), *d*.
Skins, picces of, *b*.
Solaneæ, *a*.
Solonaceæ, *a*.
Sorghum, *a*; *b*; *f*, xi. 436.
Sparganium family, *a*.
Spartium (Spanish broom), *a*; *e*, iii. 594, x. 199, xvii. 171.
Spartina juncea, *b*.
Spartina cynosuroides (cord grass), *b*.
Spindle-tree, *c*.
Sprucc fire-wood, *d*
Sterculia urens, *e*, xvi. 17.
Stinging nettle, *d*.
Stipa tenacissima, *a*.
Stone, *c*.
Straunonium or stinkweed, *b*.
Straw, *a*; *b*; *e*, xiii. 117; *f*, xi. 6, 20, 45, 325, 411, xii 19, 43, xiii. 341, 364, xv. 1, 187; *e*, iii. 449, 519, 557, 593, v 13, 63, 109, 126, vi 211, 319, ix 184, x. 93, 202, xi. 38, xvi. 13, 127, xvii. 38, xx. 1; *f*, v. 51, 144, xv 152.
Straw, barley, *d*.
Straw paper. Books printed on Koops's "Historical Account," 1800.
Stypa spartum, *a*.
Sugar-cane, *a*; *e*, xiii. 117; *g*, ii. 113.
Sultana bark, *c*.
Sunflower, *a*; *e*, xvi. 13.
Sunn, *e*, xiii. 126.
Sweet broom, *e*, xiii. 117.
Tan, *e*.
Tan bark, etc., *b*; *e*, iii 519, vi. 124, 287, x. 252; *g*, ii. 89.
Tan (spent), *a*.
Tarred rope, *f*, x. 6, xi. 292.
Terebinthenacæ, *a*.
Thistle down, *d*.
Thistle stalks, *d*.
Thistles, *a*; *e*, xiii. 117; *f*, ii. 126; *g*, ii. 24.
Tillandsia, *a*.
Tobacco, *a*; *e*, xi. 126.
Tow, *c*; *d*; *e*, iii. 519, vii. 121, x. 17, 119, 353.
Tracena endivisa, *b*.
Tree moss, *d*.
Traphis, *e*, xviii. 4.
Tulip leaves, *d*.
Turf, *a*; *d*; *e*, iv. 671, vi. 210, 249, xi. 147, xxii. 171; *g*, ii. 150.
Turnips, *a*.
Twitch grass, *a*.
Typha, *d*; *e*, xvii. 170.
Typha lutefolia, *b*.
Ulmus, *a*.
Ulva marina, *c*.
Urticeæ, *a*; *e*, xiii. 126, xiv. 17.
Usnea, *d*.
Vareek, *e*, xvii. 171; *f*, xi. 427.
Velloziæ, *a*.
Vines, grape, *d*.
Vines, hop. *d*.
Walnut leaves, *d*.
Wasps' nests, *d*.
Water broom, *c*.
Water lilies, *a*.
Water moss, *d*.
Water plants, *a*; *e*, iii. 519.
Water weeds, *a*.
Wayfaring tree, *c*.
Weeds, *b*.
Wheat straw, *b*.
Whin, *a*.
Whitewood, *c*.
Willow, *a*; *e*, xiii. 117, xviii 9.
Willow, inner bark, *d*; *e*, v. 557; *g*, 31, 32, 33.
Willow twigs, *c*.
Willow wood, *d*.
Wood, etc., *a*; *b*; *e*, iii. 463, 519, v. 94, vi. 211, vii, viii. 241, 375, ix. 183, x. 148, xi. 78, 81, 161, 177; Supplement, 16; *f*, vi. 129, 197, vii. 23, 129, 135, 137, ix. 241, xiii. 184, xiv. 65, 273, xv. 150, xvi. 120; *g*, ii. 36.
Woolen, *a*; *g*, ii 134.
Woolen grass (*Typha*), *d*.
Wrack grass, *a*.
Yellow wood after extracting dye, *d*.
Yucca filamentosa, Yucca angustifolia, Agr. Dep't Museum, 1868, *e*, xiii. 126.
Zopissa, *e*, xvi. 7, 68.

In the modern process of paper-making, the rags, linen or cotton as the case may be, are sorted by hand into various qualities, proper for different kinds of paper, the best and finest of course being selected for the stock from which the better qualities of writing-paper are to be made.

The sorting is done by women and children, who work at tables covered with wire-net. Each table has a stationary knife at its edge, against which the rags are drawn so as to divide them into shreds, the dust and dirt falling through the meshes into a receptacle below. The sorted rags are next washed

with hot water and alkali, usually in a circular pan similar to the *bucking keir* employed in bleaching, and are afterward reduced to pulp by the rag-engine. It was formerly customary to allow them to ferment or rot by steeping them for several weeks in vats; but this practice, occasioning great loss and sometimes injuring the rags by discoloration, has caused the process to be superseded by the treatment of boiling in alkaline lye, by which a large saving is effected. The fermentation, however, materially assists in the process of disintegration, rendering the pulping comparatively easy. Pulping was formerly effected by beating in mortars of hard wood having an iron bottom provided with teeth, the pestles or hammers being grooved so as to cut the rags to pieces. The hammers were either so arranged as to rise and fall perpendicularly, like the stamps of an ore-crusher, or else were so disposed as to operate in the manner of a trip-hammer. The mortars were finally superseded by the rag-engine, which was invented in Holland about the middle of the seventeenth century, and which still maintains its place in the manufacture. Of these two are employed, sometimes arranged one above the other so that the stuff when partially pulped in the upper one may be let down into the lower. The two are alike in general construction, consisting of an oblong trough with semicircular ends. They are made of wood lined with lead, or may be entirely formed of cast-iron. The trough is divided by a longitudinal partition, on one side of which is journaled a revolving cylinder provided with teeth. This cylinder is capable of being raised or lowered, and works against a block fixed in the lower part of the trough, which is also provided with cutters corresponding to those of the cylinder.

The first or upper machine is termed the *washer*, as into it the rags, after being boiled in lye, as previously described, are introduced. A current of water is allowed to flow through the trough, and the roller, in its elevated position, is set in motion, which thoroughly washes and cleanses the rags. The roller is then lowered in its bearings and the speed of rotation increased, causing a constant current circularly around the trough, carrying the pulp between the roller and the block until it is reduced to what is technically known as *half-stuff*, which is then transferred to the second engine, known as the *beater*. During this part of the process the bleaching material is added. The beater or pulping-engine is precisely similar to the washer, but its roller and block are provided with a larger number of cutters, and it is driven at a higher speed. Size, and smalt for imparting a blue color to the paper, were formerly added at this stage of the process, but the latter practice has now fallen into disuse. It is a pity that the same cannot be said with regard to barytes and other substances employed to impart whiteness and factitious weight to the paper, so as to make a very inferior article appear good to the unpracticed eye.

The pulp in its finished condition is called *whole stuff*, and is run into a reservoir, whence it is taken out as wanted to supply the vats.

Formerly, all paper was made by hand, and it is believed that a better article can be produced in this way than machine made. However this may be, machine-made paper has carried the day, and is now, perhaps, the only kind made in this country, though in England and the Continent of Europe *hand-laid* writing-paper is still manufactured.

The process is as follows: The pulp, after having been sufficiently comminuted in the beater, is transferred to the vat whence it is to be molded into sheets of paper. The *mold* is a shallow rectangular frame, having a top composed of close parallel longitudinal wires, which are crossed at more distant intervals by transverse wires of larger size. The marks of these wires are very evident in examining old specimens of paper. The water-mark is also inwoven into the mold, so as to leave its impress in the pulp in a way which cannot afterwards be eradicated. To the mold is applied an open rectangular frame, called the *deckle*, the interior dimensions of which exactly correspond with those of the intended sheet of paper. It is held closely against the mold by the hands, and the two together are dipped into the vat containing the pulp and withdrawn horizontally, leaving a layer of pulp on the mold, to which a horizontal vibration is given while the water is draining off, in order to insure a uniform distribution of the pulp and consequent uniformity in the thickness of the paper. When sufficiently drained, the deckle is removed from the mold, and the sheet of paper, now partially solidified, is transferred to a sheet of felt and covered with another sheet of the same material, on which another sheet of felt is laid, and so on alternately until a pile, usually of six quires, has accumulated, when the whole is transferred to a press, in which they are kept until an equal amount has again accumulated, when the first are removed, the alternating sheets of felt withdrawn, and the paper itself without the intermediate felts is again subjected to pressure. It is then hung up to dry on racks overhead, two or three sheets deep, sized by dipping in a solution made from the clippings of leather and parchment, again dried and pressed, examined and sorted. The blueing previously referred to constituted a part of the sizing process. Smalt was formerly employed for this purpose, but was finally, to a great extent, superseded by ultramarine, which latter, however, had the disagreeable result of allowing the gelatine size to decompose, thus imparting a most offensive smell to the paper, as may be well recollected by those of our readers who may have been brought in contact with the blue writing-papers at one time so much in vogue.

In 1798, Robert announced that he had discovered a means of making by machinery paper of large size, even 12 feet wide and 50 feet long; and in the succeeding year the invention was carried into practical effect at the paper-mill of François Didot, at Essonc, France, in whose employment Robert was at the time. The invention was patented in this year. In 1800, a reward of 8,000 francs was granted by the French government to Robert, and permission was granted him to carry his working model to England, where, in fact, the invention was first brought into practical working form.

Gamble, in 1801, obtained a patent for a machine similar to that of Robert, but the credit of introducing the machine into England is due to the Fourdriniers and Donkin, the former of whom furnished the capital and the latter the skill. Donkin completed his first machine, acting on the ideas of Robert, in 1803; and in the succeeding year, Henry and Sealy Fourdrinier purchased the patents of Didot and Gamble. These gentlemen may be considered as the great introducers of machine-made paper, and, like many other projectors, were rewarded by impoverishment.

The Fourdrinier machine (1) receives the pulp on an endless web of wire-cloth, which passes over rollers. The Dickenson machine (2) employs a perforated cylinder, which serves as a substitute for this endless web. See Plate XXXVII., PAPER-MAKING MACHINE, where several kinds of paper and cardboard machines are represented.

Two hundred and ninety-nine Fourdrinier machines were running in the United States in 1872.

In 1809, Mr. Dickenson, an English paper-maker, invented the cylinder machine, in which a polished hollow brass cylinder, perforated with holes and covered with wire-cloth, is substituted for the endless wire-web of the Fourdrinier machine. In this the air is exhausted through the trunnions or axis of the machine. (See Plate XXXVII.) In the year 1872, 689 cylinder machines were running in the United States.

The patents on the subject of paper-making are very numerous. Donkin, however, who devoted so much time and talent to the matter, undoubtedly is entitled to the first rank after Robert, who suggested the idea of making paper in a continuous web.

One great difficulty to be obviated was the wetness of the sheet of pulp, which, of course, impaired its tenacity, rendering the manipulations exceedingly difficult. This was, in a large degree, removed by the invention of the *dandy* by Wilkes, patented in England in 1830. This is a hollow perforated roller, corresponding to the *doffer* of a carding-machine, over which the paper is caused to pass and is pressed under another roller. The dandy may be so constructed as to exhaust the air from beneath the paper by forming it of an inner and exterior casing of sheet-metal, but in practice this has not been found necessary.

The introduction of threads, net, or other woven material into the paper is described in Dickenson's English patent, 1809.

In the machine-made papers the trouble of assorting, trimming, and hanging up to dry is entirely avoided, a perfectly uniform thickness is attained, the time required to produce a sheet from the pulp is reduced from weeks to minutes, and sheets of indefinite length may be produced; for example, a sheet was made at Colinton, England, in 1839, on the Fourdrinier machine, over a mile long, 50 inches wide, and weighing 533 pounds. This length might perhaps be extended indefinitely.

Dickenson, who has been already mentioned as the inventor of the cylinder paper-machine, invented a paper composed of two webs of different texture, which were united while in a pliant condition, so as to render them inseparable; the web constituting the face was made of finer material than that intended for the back. This paper was particularly designed for copperplate printing. To prevent counterfeiting special papers have been devised, such as that used by the Bank of England and by the United States Treasury Department. In these cases the difficulty of manufacturing a similar article is relied on to prevent fraud; complicated and expensive machinery, not within the reach of ordinary counterfeiters, being required. The paper on which United States currency is printed contains silk fiber mixed with the pulp, producing a peculiar appearance, which is readily recognized, and which would be difficult, if not impossible, to imitate without the aid of the peculiar machinery by which the paper is produced.

A paper has also been made with a knitted fabric inclosed, which leaves an unerasable mark on the back of the fabric, and prevents all erasures and alterations of writing on its surface.

Analine (*an*, priv., without *line*, i. e. flax) is a name applied to paper destitute of flax, and must not be confounded with *aniline*.

Sponge paper is made by adding finely divided sponge to ordinary paper pulp. The paper absorbs moisture readily and retains it for a long time. It has been used to advantage for dressing wounds, and is capable of several important technical applications.

Incombustible paper and cloth were made of asbestus in the time of Pliny. The pulp is prepared in the usual manner from a pulp consisting of vegetable fiber, asbestus, alum, and borax, in about the following proportions: Vegetable fiber, one part; asbestus, two parts; borax, one tenth part; and alum, two tenths of a part. The vegetable fibers are minutely divided, and treated in the manner usual in the production of ordinary paper; the asbestus is also divided as much as possible, and the two are then intimately mixed with the alum and borax in a sufficient quantity of water to make a pulp of the requisite consistency, which is then made into paper by any of the well-known processes.

The fire-proof ink for writing or printing on incombustible paper is made according to the following recipe: Graphite, finely ground, 22 drams; copal or other resinous gum, 12 grains; sulphate of iron, 2 drams; tincture of nutgalls, 2 drams; and sulphate of indigo, 8 drams. These substances are thoroughly mixed and boiled in water, and the ink thus obtained is said to be both fire-proof and insoluble in water. When any other color but black is desired, the graphite is replaced by an earthy mineral pigment of the desired color. Paper is rendered transparent by a varnish composed of Canada balsam dissolved in turpentine.

Carbolic-acid paper is now much used for packing fresh meats for the purpose of preserving them against spoiling. The paper is prepared by melting five parts of stearine at a gentle heat, and then stirring in thoroughly two parts of carbolic acid, after which five parts of melted paraffine are added. The whole is to be well stirred together till it cools, after which it is melted and applied with a brush to the paper, in quires, in the same way as in preparing the waxed paper so much used in Europe for wrapping various articles.

Sizes of Papers.

Printing Papers.

	Sheet.	Folio.	4to.	8vo.	16mo.	32mo.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Demy	22½×17½	17½×11¼	11¼× 8¾	8¾× 5½	5½× 4¾	4¾×2¾
Medium	24 ×19	19 ×12	12 × 9½	9½× 6	6 × 4¾	4¾×3
Royal	25 ×20	20 ×12½	12½×10	10 × 6¼	6¼× 5	5 ×3½
Super-royal	27½×20½	20½×13¾	13¾×10¼	10¼× 6¾	6¾× 5¼	5⅛×3½
Imperial	30 ×22	22 ×15	15 ×11	11 × 7½	7½× 5½	5½×3¾
Double foolscap	27 ×17	17 ×13½	13½× 8½	8½× 6¾	6¾× 4¼	4¼×3¼
Double crown	30 ×20	20 ×15	15 ×10	10 × 7½	7½× 5	5 ×3¾
Double post	32 ×20	20 ×16	16 ×10	10 × 8	8 × 5	5 ×4

Drawing Papers.

Emperor	72 ×48	48 ×36	36 ×24	24 ×18	18 ×12	12 ×9
Antiquarian	53 ×31	31 ×26½	26½×15½	15½×13¼	13¼× 7¾	7¾×6½
Double elephant	40 ×26¾	26¾×20	20 ×13¾	13¼×10	10 × 6½	6½×5
Atlas	36 ×26	26 ×18	18 ×13	13 × 9	9 × 6½	6½×4½
Columbia	34½×23¼	23½×17¼	17¼×11¾	11¾× 8½	8½× 5¾	5¾×4¼
Imperial	30 ×22	22 ×15	15 ×11	11 × 7½	7½× 5½	5½×3¾
Elephant	28 ×23	23 ×14	14 ×11½	11½× 7	7 × 5¾	5¾×3½

Writing Papers.

Super-royal	27 ×19	19 ×13½	13½×9½	9½×6¾	6¾×4¾	
Royal	24 ×19	19 ×12	12 ×9½	9½×6	6 ×4¾	
Medium	22 ×17½	17½×11	11 ×8¾	8¾×5½	5½×4¼	
Demy	20 ×15½	15½×10	10 ×7¾	7¾×5	5 ×3¾	
Large post	20¾×16¾	16¾×10½	10½×8¼	8¼×5⅛	5⅛×4⅛	
Small post	19 ×15¼	15¼× 9½	9½×7½	7½×4¾	4¾×3¾	
Foolscap	17 ×13½	13½× 8½	8½×6¾	6¾×4¼	4¼×3¼	

Copperplate papers are made the same size as drawing-papers down to *medium*. Below this they are cut by the printer. The paper is more absorbent than *drawing*-paper.

This absorbent paper is without size, and is known as *soft plate*.

When engravings are to be colored, they are printed on sized drawing-paper, which is known as *hard plate* when used in this connection.

See under the following heads: —

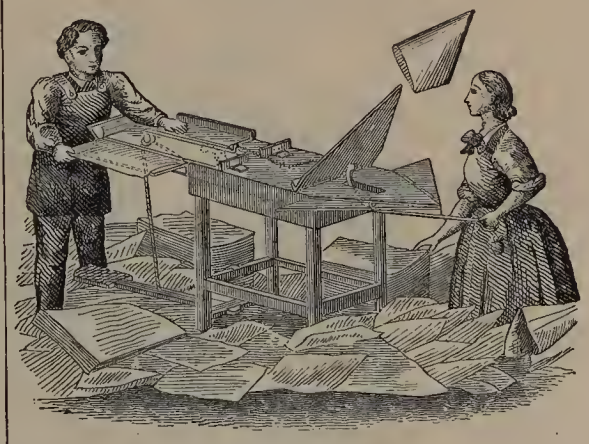
Addressing-machine.
Antiquarian paper.
Ass.
Atlas-paper.
Autographic paper.
Bark-paper.
Bath note-paper.
Beating-engine.
Bill-holder.
Billet-note.
Binder's board.
Blotter.
Blotting-paper.
Board.
Bond-paper.
Bristol board.
Bronzing.
Brown paper.
Calendering-paper.
Cap-paper.
Card-board.
Card-cutting machine.
Carton.
Carton-pierre.
Cartridge-paper.
Case-paper.
Cloth-paper.
Columbier.
Copy-paper.
Copying-paper.
Cosaques.
Cotton-paper.
Cross-rule paper.
Crown-paper.
Curtain-paper.
Cylinder-engine.
Dandy.
Deckle.
Demy.
Devil.
Diluting roller.
Doctor.
Double-cap.
Double-elephant.
Double-imperial.
Double-medium.
Double-royal.
Double super-royal.
Drawing-paper.
Drum-paper.
Drying-paper.
Dry-press.
Duster.
Elephant.
Embossed paper.
Embossing-machine.
Enameled board.
Enamel-paper.
Engine-sized.
Envelope.
Envelope-dryer.
Envelope-machine.
Exchange-cap.
Fanning-out.
Filer.
Filtering-paper.
Finisher.
Flat cap.
Flock.
Folding-machine.
Foolscap.
Forming-cylinder.
Fourdrinier-machine.
Glazed board.
Glazing-machine.
Half-stuff machine.
Hog.
Hot-press.
Imperial.
India-paper.
Inkstand.
Ivory-paper.
Knotter.
Label.
Lace.
Laid-paper.
Letter-clip.
Letter-file.
Letter-paper.
Letter-stamping machine.
Lifter.
Linen-paper.
Lithographic paper.
Littress.
Mailing-machine.
Manilla-paper.
Map and chart holder.
Marble-paper.
Medium.
Metallic paper.
Mill-board.
Music-paper.
Nepaul-paper.
Newspaper clamp.
Newspaper-folder.
Oiled paper.
Paper-bag machine.
Paper-boat.
Paper-box machine.
Paper-clip.
Paper-cloth.
Paper-collar.
Paper-coloring.
Paper-cutting machine.
Paper-enameling machine.
Paper floor-cloth.
Paper-folding machine.
Paper-gage.
Paper-hanging.
Paper hot-pressing.
Paper-knife.
Paper-making machine.
Paper-mold.
Paper-muslin.
Paper-punch.
Paper-polishing machine.
Paper-size.
Paper-splitting.
Paper-stock bleacher.
Paper-stock washer.
Paper-tube machine.
Paper-twine.
Papier-maché.
Parchment-paper.
Pasteboard.
Pasteboard-cutter.
Peel.
Perforating-machine.
Porcelain-paper.
Portfolio.
Post.
Potcher engine.
Pottery-tissue.
Pott.
Pounce paper.
Printing-paper.
Profile-paper.
Protective paper.
Pulp
Pulp-boiler.
Pulp-dresser.
Pulping-machine.
Pulp. Making articles from
Pulp-mill
Pulp-washer.
Quire.
Rag-dusting machine.
Rag-engine.
Razor-paper.
Ream.
Register.
Rice-paper.
Roll-blotter.
Roofing-paper.
Rotary cutter.
Royal.
Ruling-machine.
Safety-paper.
Sheathing-paper.
Stamp-attacher.
Straw-board.
Straw-boiler.
Straw-paper.
Stuff-chest.
Stuff-engine.
Stuff-shovel.
Super-royal.
Tar-board.
Test-paper.
Tinted paper.
Tip-paper.
Tissue-paper.
Tobacco-paper.
Token.
Toned paper.
Touch-paper.
Tracing-paper.
Transfer-paper.
Tribble-paper.
Vegetable-parchment.
Velvet-paper.
Wall-paper.
Wall-paper cutter.
Washer.
Water-mark.
Water-proofing paper.
Wet-press.
Wood-paper.
Wove-paper.
Wrapping-paper.
Writing-case.
Writing-paper.

Pa'per-bag Ma-chine'. A machine, usually automatic, operating upon paper from the roll or upon blanks previously cut, to fold and paste it into bag shape.

The kinds are various, and the prominent ones will be cited in order of date. The principal and most successful ones take the paper from the roll, either of a width for forming a bag, or else cut into strips which are simultaneously acted upon by separate sets of devices. The strip, assuming there to be but one, is bent over into tubular shape, cut off into lengths, the shape at the point of severance being such as to leave a flap to paste over, and thus close the bottom; or a piece is cut off the flat strip and portions of it are folded over the remainder and flaps pasted for closing the side and bottom; or a piece is folded into a conical form with pasted flap. Other minor variations might be cited. Much of the ingenuity has been expended in cutting the paper to make no waste; also in forms for so folding the portions at the bottom as to make what is called a satchel-bottom, where the parts are folded upon each other, making several thicknesses at the part most exposed to wear and tear.

Fig. 3505 is a hand-machine, having two ends at which square and conical bags are made respectively. In such case, a piece of paper of the required size and shape is laid upon the table and held by a hinged piece which corresponds to the inner size and form of the bag; this former, holding down the sheet, side flaps are folded over, carrying with them portions of the paper

Fig. 3505.

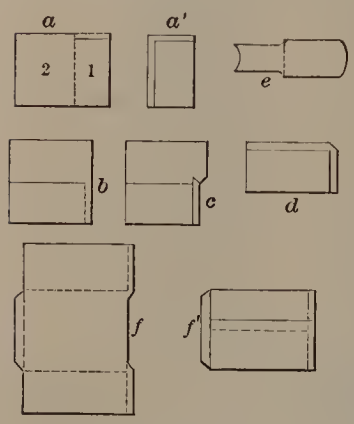


Paper-Bag Machine.

which lap upon each other a sufficient width for a pasting surface. One machine is shown operated by a hand-lever, the other by a treadle. The farther one, for square bags, has a bottom flap for the bottom piece, which folds over upon and is pasted to the side pieces.

Wolle, October 26, 1852, and May 29, 1855, was perhaps the first to make bags by automatic machinery. The bag made is shown at *a a'*, Fig. 3506. *a* is the blank with a notch; the portion 1 is folded over the part 2, and then appears as represented at *a'*. The folding over of the top and bottom flaps fin-

Fig. 3506.



Blanks for Paper Bags.

ishes the operation. The paper is fed from a roll, the web is cut into oblong sections, notched, folded by a blade which drives the bottom edge between rollers, from whence the folded blank passes to the gummers and flap-folders.

b c d shows a bag in successive stages as made in Wolle's machine of July 6, 1858. The piece is not removed to form the notch, but is folded in to make double the bottom of the bag.

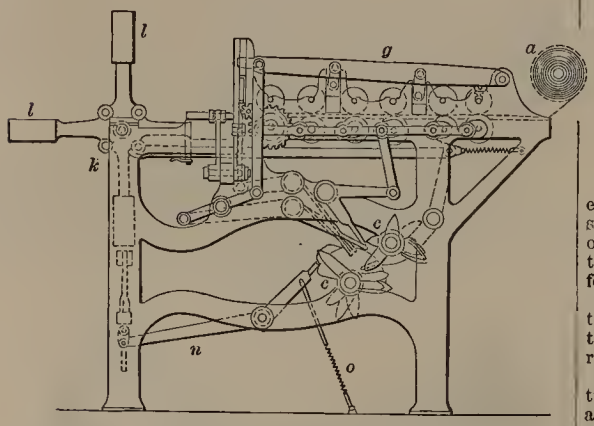
The Rice machine, April 28, 1857, was the first to bend a continuous web of paper over into a tubular shape and cut it off obliquely, so that an angular piece is left to be bent over and form the flap of the bag-bottom.

e represents a blank cut from a continuous web in a Goodale machine, May 29, 1855. The narrower portion is folded on to the wider, and the side flaps pasted and turned down. The bag has a projecting lip, due to the curved line of severance.

f f' shows Goodale's paper bag, July 12, 1859. This cuts from the web without waste, and the bottom has two flaps, strengthening it at that point. See also his patent, Aug. 23, 1859.

Koch's paper-bag machine, March 13, 1855, is adapted for making bags or boxes, the paper from a continuous web *a* being drawn between successive sets of rollers, etc., which are caused to turn intermittingly in one direction by means of cams on a shaft operating jointed levers and connecting rods. As the paper moves onward it is cut to the proper form and size by a cutter or cutters vertically reciprocated by the lever *g*, which,

Fig. 3507.



Koch's Paper-Bag Machine.

together with a corresponding lever on the other side, derives its motion through an intermediate series of levers from cams on the shafts *c c*. The lever *g* also operates the paster.

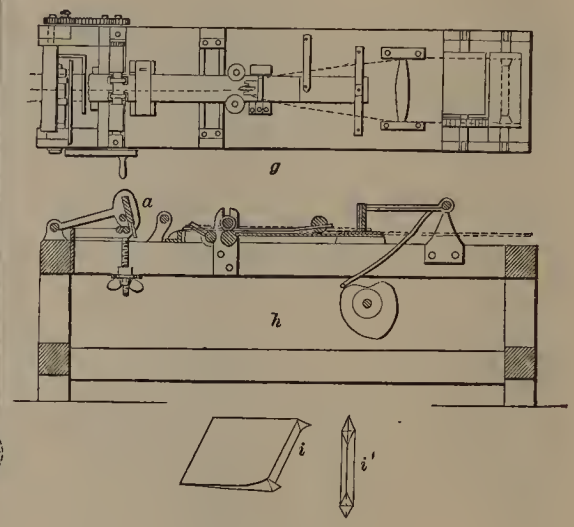
After being pasted the blank is carried forward by the two succeeding pairs of rollers and received upon a slide which forms one side of a hollow mold within which the bag is formed; at the same time the shaft *k* is rotated one quarter around, so that one of the formers *l* is in proper position to permit slides corresponding to the three other sides and the bottom of the bag to be successively brought up against it; this is effected by cams on the shafts *c c*, which operate compound levers connected with the slides and having toes against which the cams strike during the rotation of the shaft.

The forward movement of each slide turns in its side of the paper upon the former *l* and joins the pasted edges. The bottom is also similarly turned in and united to the sides. Farther rotation of the shafts *c c* causes the withdrawal of the slides and imparts a movement to the *former*, on which is the completed bag. This is withdrawn from the *former* by a pair of nippers or pinchers, which are caused to rise at the proper moment and seize the bag, by the bent lever *n* actuated by a spring *o*. The nippers is withdrawn, taking with it the bag, by a semicircular cam on the shaft *c*, its jaws being opened and closed at the right time by projections on the standards between which it works.

Pettee's machine, May 29, 1860. The roll of paper is fed beneath an elevated roller, and, passing over and partially around a drum, passes beneath the folder, which consists of two longitudinal strips with an opening between them, through which one edge of the paper projects, enabling paste to be applied by means of a horizontally revolving paste-wheel. Passing onward, it is seized by two clamps, drawn over a slide, and the two sides united so as to form a tube. As it is released by these clamps, it is seized by a second pair, which pass over the first, drawing it forward by a hand-over-hand movement, and passing it between the two blades of a stationary clamp, which holds it while it is severed by a reciprocating knife. It is then subjected to the action of a wedge-shaped trough containing paste. The lower edge of this trough has a longitudinal slit, the width of which may be adjusted so as to deposit the proper quantity of paste on the bottom of the cut-off bag. At the moment of depositing the paste the edge of the trough forces this part between two rollers, which bend over the edge of the bottom and complete the bag. The various motions requisite to the operation of the machine are derived from a driving-shaft, having belt and pulley connection with the motor.

g, Fig. 3508, represents the Armstrong machine, October 2, 1860. The bag is made from a continuous web, bent by a spindle-shaped roller and by side guides into a tube, the lapping

Fig. 3508.



Paper-Bag Machines.

edge pasted, the tube flattened, and then a bag cut off. The sides of the bag are held apart at different parts of the length of the tube, so that a single stroke makes an oblique cut across the tube of paper. The projecting serrated flap is pasted and folded over upon the body of the bag.

Greenough's machine, February 3, 1863, works from a continuous web, making square-bottomed, box-shaped bags, portions being removed from each side of the strip to make the requisite indentations and flaps.

Pettee, May 5, 1863, bends a continuous web of paper into a trough shape, by a pair of rollers adjustable in relative distance according to size of bag. Then the edges are bent over by another roller to form a tube, the edges gummed, a portion cut off obliquely to make a bottom flap.

Taggart, August 15, 1865, has a table with a slit which holds the flatly folded bag, exposing that portion above the table which is to be folded satchelwise.

h is the Goodale machine, September 12, 1865. The continuous web is cut by the descending knife *a*, giving the edge of the blank a wavy shape. The sides are then folded over by side flaps, the folded portions lapping over each other the width of the pasted surface. The bottom flap is turned over and pasted on to the sides.

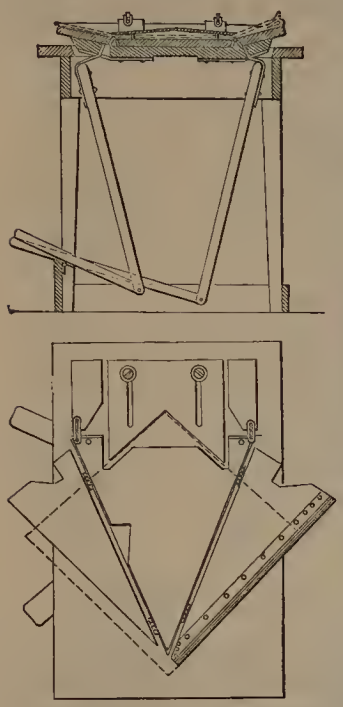
i i' are two views of the Hollingsworth bag, January 24, 1865, which is made upon a vertical former with dilatable sides.

Jaeger's machine, May 7, 1857, is shown in Fig. 3509. It is somewhat similar to the one shown at Fig. 3508. It takes a square blank and folds over two angular flaps, making a conical bag.

Mallary's machine, July 28, 1868, like the Goodale machine just cited, has side and end flaps which fold those portions over the former. As the continuous sheet of paper is fed to the machine, the several devices perform their respective functions of delivering the paper to a knife, which cuts off a piece of suitable length for a bag, drawing such piece into the folders which produce the side laps, pressing the end lap against the pasting-roller, and at the same time turning it upward over the edge of the folding-blade, and then moving the bag forward between pressure-rollers, which join the pasted edges of the laps to the bag.

In his patent of November 3, 1868, one edge of the sheet is

Fig. 3509.



Jaeger's Paper-Bag Machines.

pasted by means of a roller as it passes into the machine; then one of its sides is folded over a former, and over it is folded the pasted side. The bag so far formed is drawn off by rollers, by which it is passed into an inclosure made with a bottom of a series of rollers, which carry it forward. One roller applies paste across the bag near the bottom, while another forms a fold for the bottom lap. It then passes out between another pair of rollers, which dress the bottom fold of the bag into place.

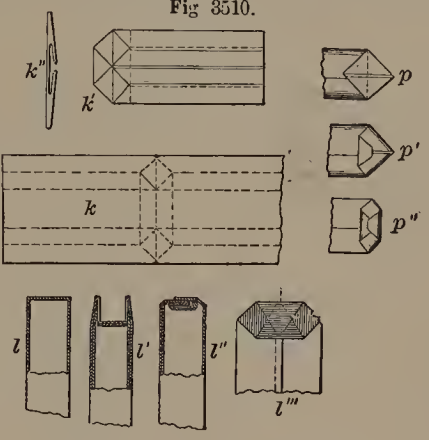
In Amazeen's machine, November 17, 1868, the paper, in passing into the machine from a mounted roll, has paste applied to its margin at one side, and is fed forward to toothed knives, which cut off a piece large enough to form a bag. The pasted and detached piece is then made to pass on beneath a plate or former, around which it is deflected into tubular form by bent guide-plates. The paper, being delivered from this forming device, has its pasted side pressed down upon the adjoining edge. One side of the paper tube is now longer than the other (a result due to the shape of the knives), and the mechanism, which finally comes into play, applies paste to the projecting end, folds it over to finish the bag, and discharges the latter from the machine.

Lockwood's machine, March 9, 1869. The web of paper is drawn over rollers *a d*, paste being applied to one edge by a roller in the trough *f*. It is partially formed in a tubular shape by the pivoted ball *g*, which prepares it for the action of the former *h*, by which, and the side clamps *i i*, the two edges are thrown over toward each other, but are prevented from touching by a finger until arriving at or near the guides and press-rollers which unite the two edges.

The tube is passed onward by a roll and endless band, which hold it firmly while being severed between the stationary serrated knife and a movable knife below it. The endless bolt *n* conveys the bag into a position to be acted on by a knife, which is brought alternately into contact with a roller revolving in a paste-trough and with the end of the bag, which it pastes and creases preparatory to being seized by the rollers which, by pressing the turned-over portion and the body of the bag, form the bottom and complete the operation.

M. E. Knight's machine, July 11, 1871, manufactures flat or satchel-bottomed bags from a continuous tube of paper fed from a roll over a former, and cut, folded, and pasted. The peculiar feature is a device to hold back a point or portion of one edge of the paper tube, while the blade or tucking-knife makes the first fold. The successive conditions of the fold are shown at *p p' p''*, Fig. 3510.

Fig 3510.

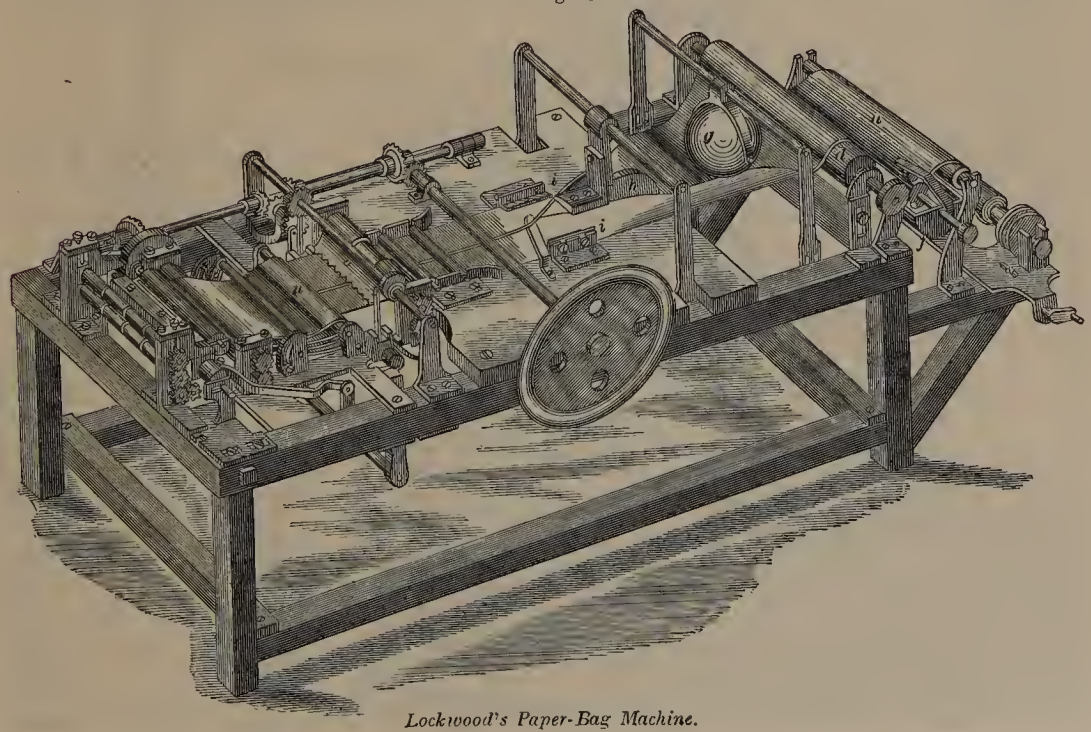


Forming a Strip into a Flat Tube.

In Arkell's machine, December 26, 1871, square-bottomed bags are made from a roll of paper, which is passed over a former, and its edges pasted together so as to be delivered in the form of a tube, which is cut into lengths, one end of which is cut, folded, and creased to facilitate the operation of forming the bottom. The partially formed sack is carried automatically through the machine on a carrier, which moves continuously in one direction, and on which it is subjected successively to the mechanism for applying the paste and finishing the bag bottom. Fig. 3510 shows the successive shapes assumed by the paper in forming a strip into a flat tube.

The Benner bag, January 9, 1872, is shown at *k k' k''*. A strip double the length of the bag to be formed is folded at mid-length. By the action of long formers, having at their sides hinged blades, the edges of the blank are folded, reverse folded,

Fig. 3511.



Lockwood's Paper-Bag Machine.

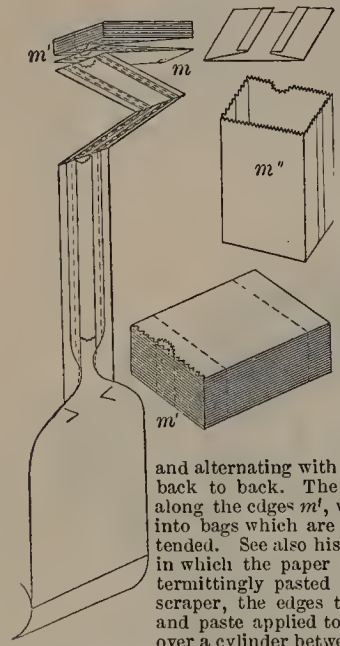
and lapped to form a tube which, when distended, is rectangular in section. See also Guild's patent, January 23, 1872.

Bibby and Baron's English machine, October 1, 1872, for making square-bottomed bags, takes the paper tube from a roll, cuts, pastes, folds, presses, prints, and delivers the completed bag.

Annan's machine, November 12, 1872. A strip of paper, one edge pasted, is fed over curved guides (carrying diagonal spreading-rolls) attached to pivoted lever-arms, and its sides turned inward and lapped by twisted guides. This tube is pressed and fed forward by rolls (between which it is cut) upon a folding-table, where its lower ply is held down and the freshly pasted seam protected by an exhaust through orifices in the bed, and the forward end of the upper ply blown up by a blast through a pipe. Three rollers, journaled in cross-heads which reciprocate in radial slots of the revolving frame, successively carry the upper ply back on the tube to form the first diamond-end fold, the tube having been clamped by fingers at the angle thus formed; then deposit two lines of paste over the laps clamped by double fingers at the points where they are next to be folded, and after a folding-plate has folded over the last flap then lap the last fold on the opposite end of the bottom, the finished bag being fed out by rolls or belts.

In Hotchkiss's machine, January 28, 1873, the bag shown at l' l'' l''' is made. The paper is fed by rolls from under the delivery-table over the recess of the folding-table, where it is held on one side by a spring and on the other by a gravitating bar, when a bag-length is cut by the shears. A right angular bar, rocked in and out of a vat, applies paste to one edge and part of the rear end. The rectangular former, descending, carries the blank into the forming-box, causing its sides to stand vertically, that which is dragged from under the bar being longest to form the overlap or seam. The folding-plate moves forward to lay one lap, followed by the opposite combined plate and roller, which lays the other flap and completes a square tube. These folding devices are so connected by levers, that one shall move in advance of the other, and the last folder plays under the pasting-table. The side-end folders are reciprocated successively to lay the side folds of the bag end, the pasted one first, over which partially completed end a paste-roll, vibrated out of a paste-vat, lays a line of paste on the inside surfaces of the top and bottom end-folds, the latter being protected by a supporting lip. The side-folders retreating, the upper end-folder descends and lays its fold, and, retreating, is followed by the lower end-folder, which completes the bottom. The *former* now rises, and, as a new feed is accomplished, its interior piston ejects the bag from the former on to a table, from which it is fed by an apron against the upper of a pair of rolls, where a vibrating bar breaks down its upper edge and forces the lower corner of the bottom into the bite of said rolls, which press and deliver it flat.

Fig. 3512.



Crowell Bag.

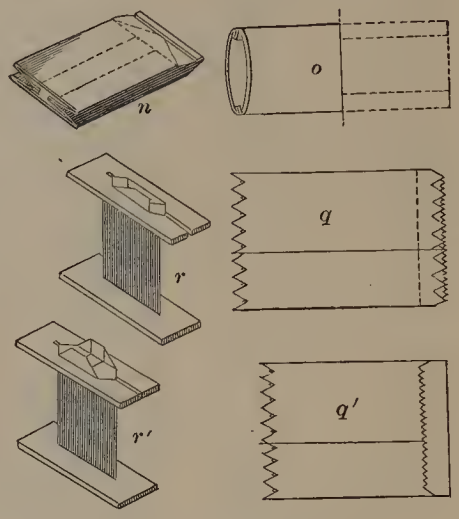
Fig. 3512 shows the Crowell bag, April 8, 1873, in which the edges of a strip of paper are folded in and then a portion lapped outwardly, the face of the latter being pasted. By doubling the strip thus prepared inward and outward, zigzag fashion, as at m, the parts become united together in pairs, faces fastening paste to paste, and alternating with unpasted portions lying back to back. The bolt thus made is cut along the edges m', which separates the pile into bags which are like m'' when fully distended. See also his patent, October 14, 1873, in which the paper is cut longitudinally, intermittingly pasted by the paste-wheels and scraper, the edges then being folded under and paste applied to them. Thence it passes over a cylinder between it and a second cylinder, when the bottom is folded, the bag-length cut off, and the edges pressed together. Then the bag passes over the printing-roll to the table, where it is automatically removed and counted.

n represents the Parker bag, January 6, 1874, which is formed by folding inwardly the opposite edges of two strips of paper, uniting the folded edges, and folding and pasting one end of the united strips.

Crowell's paper-bag, January 13, 1874. *o* has a bottom made by a central transverse fold of the paper, and has its sides closed by edge-folds which, at each side of the paper, are cemented together and to one of the adjacent sides of the bag.

q q' illustrate Murphy's mode of making the division of the paper tube so that when the side portions, which are deeply serrated, are folded over upon the mid portion, both will be exposed to the pasting-brush, as shown at q, and may be securely fastened down to the side of the bag over which the bottom flap is folded.

Fig. 3513.

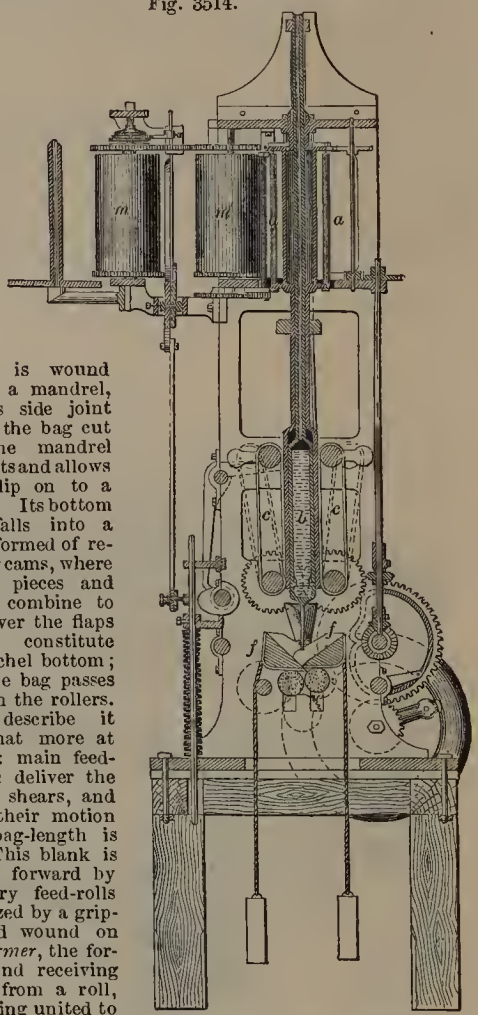


Paper Bags.

r r' illustrate the mode of making the Taggart bag, the blank being slipped into a slit plate, and then the portion projecting above the plate being folded down, first the ends and then the sides.

Biedinger's, March 10, 1874, is an upright machine in which the web of paper is fed upon its edge between a pair of vertical

Fig. 3514.



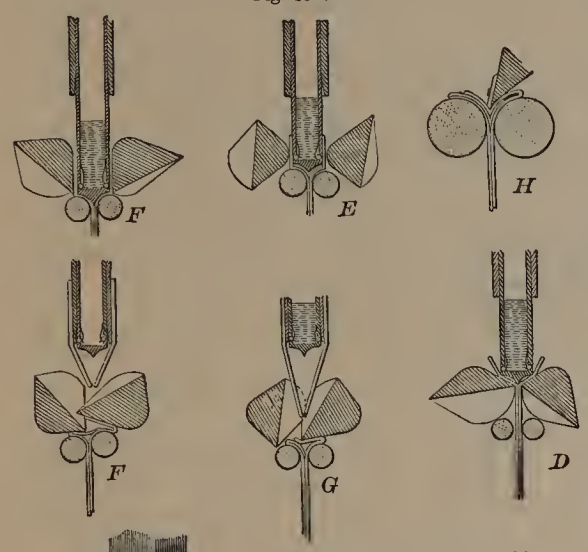
Biedinger's Paper-Bag Machine.

rollers, is wound around a mandrel, and, its side joint pasted, the bag cut off, the mandrel contracts and allows it to slip on to a former. Its bottom then falls into a cradle formed of revolving cams, where folding pieces and fingers combine to bend over the flaps which constitute the satchel bottom; and the bag passes between the rollers.

To describe it somewhat more at length: main feed-rolls m deliver the web to shears, and cease their motion as a bag-length is cut. This blank is carried forward by auxiliary feed-rolls m', seized by a gripper, and wound on the *former*, the forward end receiving paste from a roll, and being united to the rear end by

pressure against the delivery-roll. The *former* consists of a set of roils *a a* on eccentric shafts, partially rotated, to expand the

Fig. 3515.



Biedinger's Paper Bag Machine (Series of Operations).

former while making the tube, and farther rotated to contract it to release the tube, which falls on to a supplemental former *b*, over which it is fed by endless belts *c c* being made to pass over spring-arms and extended flat, and into the discharge-rolls, which propel it until a proper length projects above the bottom-folders. Folders *f f* now move inwardly, pressing against the retiring spring-arms, and form the triangular end-folds (Fig. *C*); retracting, they are followed by the descending piston, which rests on this partial bottom (Fig. *D*). The continuously revolving folders crease the sides against the angles of the piston, press a line of paste thereon, carry the piston and bag downward together until the central rib of the piston enters and spreads the bag-bottom in the bite of the discharge-rolls (Fig. *E*), where, the piston rising, the folders lay the side-laps successively (Figs. *F*, *G*), one folder (Fig *H*) carrying a knife, folding the bottom centrally and into the rollers which discharge it pressed flat for packing

PAPER-BAG MACHINES PATENTED IN THE UNITED STATES.

No.	Name.	Date.
9,355,	F. Wolle,	Oct. 26, 1852.
12,511,	Louis Koch	March 13, 1855.
12,786,	Smith and Pettee	May 1, 1855.
12,945,	E W. Goodale	May 29, 1855.
12,982,	F. Wolle	May 29, 1855.
13,647,	E. W. Goodale	Oct. 9, 1855.
17,184,	B. F. Rice	April 28, 1857.
19,506,	Jacob Keller	March 2, 1858.
20,838,	Francis Wolle	July 6, 1858.
21,657,	Henry R. David	Oct. 5, 1858.
22,199,	S. E. Pettee	Nov. 30, 1858.
24,734,	William Goodale	July 12, 1859.
25,191,	William Goodale	Aug. 23, 1859.
27,959,	Louis D. Barrand	April 24, 1860.
28,188,	G. F. Lufberry	May 8, 1860.
28,537,	S. E Pettee	May 29, 1860.
30,191,	H. G. Armstrong	Oct. 2, 1860.
32,777,	John Miller, Jr.	July 9, 1861.
37,573,	J. J. Greenough	Feb. 3, 1863
37,726,	C. H. Morgan	Feb. 17, 1863.
38,253,	Joseph Wells	April 21, 1863.
38,452,	S. E. Pettee	May 5, 1863.
40,001,	Joseph Wells	Sept. 15, 1863.
42,313,	Joseph Wells.	April 12, 1864.
43,773,	J. M. Hurd	April 12, 1864.
45,939,	E. A. Hollingsworth	Jan. 24, 1865.
49,454,	B B. Taggart	Aug 15, 1865.
49,733,	B. F. Ellis	Sept. 5, 1865.
49,951,	E. W. Goodale	Sept. 12, 1865.
62,342,	Kirk and Howlett	Feb 26, 1867.
64,537,	G. L. Jaeger	May 7, 1867.
70,601,	E B Olmsted	Nov. 5, 1867.
74,190,	James Arkell	Feb. 11, 1868.
80,298,	George H. Mallary	July 28, 1868.
83,648,	George H. Mallary	Nov. 3, 1868.
84,076,	C. Amazeen	Nov. 17, 1868.
87,608,	Joseph Wells	March 9, 1869.
87,689,	H. C. Lockwood	March 9, 1869.
90,624,	C. F. Annau	June 1, 1869.
94,511,	J. P. Pultz	Sept. 7, 1869.
101,299,	C. J. Moffatt	March 29, 1870.
104,169,	H. Law	June 14, 1870.
105,099,	Lorton and Davison	July 5, 1870.
110,536,	C. F. Annau	Dec. 27, 1870.
111,802,	C. F. Annan	Feb. 14, 1871.
111,803,	C. F. Anuan	Feb. 14, 1871.
112,005,	P. E. Armstrong	Feb. 21, 1871.
114,743,	A. Adams	May 16, 1871.
116,842,	M. E Knight	July 11, 1871.
118,327,	James Arkell	Aug. 22, 1871.
119,307,	J. M., J. P., and S. H. Bryant	Sept. 26, 1871.
119,915,	B. S. Binney	Oct. 17, 1871.
122,099,	James Arkell	Dec. 26, 1871.
122,510,	L. D. Benner	Jan. 9, 1872.
123,013,	George Guild	Jan. 23, 1872.
123,812,	L. C. Crowell	Feb. 20, 1872.
131,841,	Bibby and Baron	Oct. 1, 1872.
132,312,	H. B. Morris	Oct. 15, 1872.
132,890,	C. F. Annan	Nov. 12, 1872.
133,395,	J. Arkell	Nov. 26, 1872.
134,035,	B. Cole	Dec. 17, 1872.
134,580,	C. F. Annan	Jan. 7, 1873.
135,145,	M. Murphy	Jan. 21, 1873
135,275,	T. Hotchkiss	Jan. 28, 1873.
138,844,	L. D. Benner	May 13, 1873.
139,104,	H. G. Armstrong	May 20, 1873.
140,342,	N. Biedinger	July 1, 1873.
141,862,	G. Dunham	Aug. 19, 1873.
143,358,	W. Liddell	Sept. 30, 1873.
143,674,	L. C. Crowell	Oct. 14, 1873.
143,925,	J. S. Ostranger	Oct. 21, 1873.
145,125,	J. P. Raymond	Dec. 2, 1873.
146,372,	W. Webster	Jan. 13, 1874.
146,773,	R. W. Murphy	Jan. 27, 1874.
146,774,	M. Murphy	Jan. 27, 1874.
147,998,	C. B. Stilwell	Feb. 24, 1874.
148,280,	C. G. Biedinger	March 10, 1874.
151,258,	W. F. West	May 26, 1874.
151,862,	G. Dunham	June 9, 1874.

Pa'per Boat. Paper boats or "shells" have of late years largely supplanted those of wood for racing and sporting purposes. These are made by applying sheets of manilla paper, or paper prepared from pure unbleached linen stock, to the exterior of a model or former corresponding to the interior lines of the shell. The sheets are fully equal in length to the model; and if manilla be employed, the first sheet is damped, applied smoothly to the surface of the model, and secured by tacking to strips on its upper face; it is then coated with an adhesive varnish, another sheet is applied over the first, and so on successively until the required thickness is attained.

When linen paper is used, but a single thickness of $\frac{1}{20}$ to $\frac{3}{8}$ of an inch is employed. The model with its envelope is then removed to a drying-room and exposed to a heat of 150° Fah., which obliterates all wrinkles in the paper and hardens it; it is next covered with boiled linseed-oil and turpentine, and afterward with shellac varnish; the framing is then inserted, and the decking and metal work put in place. Such boats may be made about one third lighter than wooden boats of the same dimensions, are impervious to water, and the skin is not liable to spring. See BOAT; CANOE.

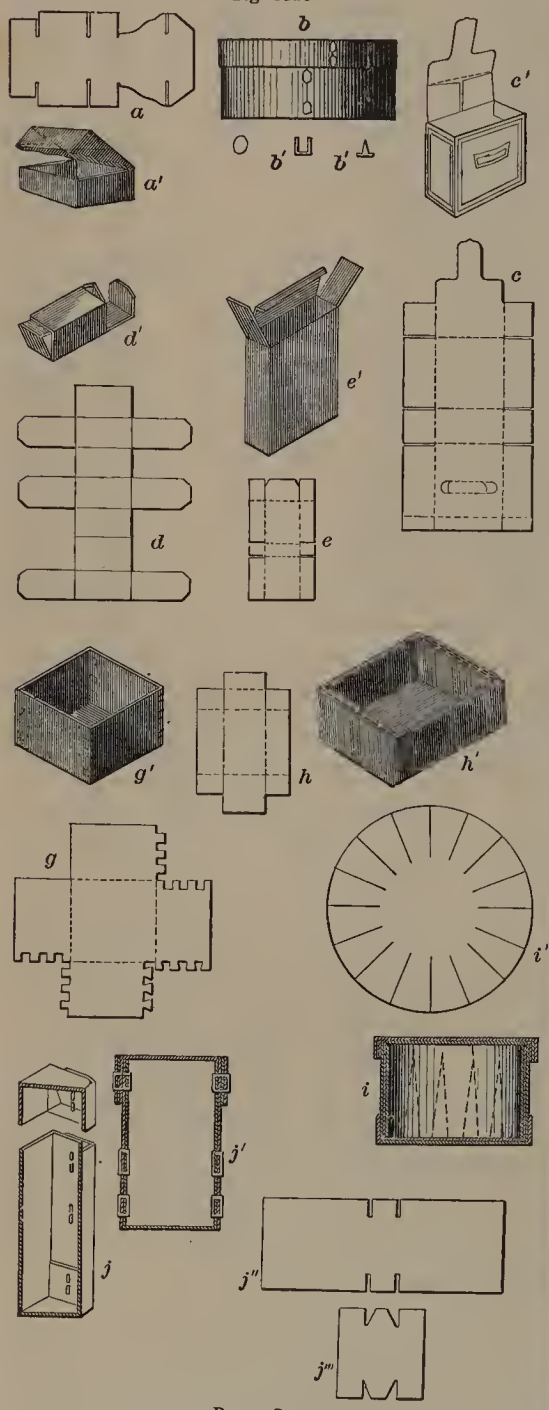
Pa'per Box. Paper boxes are made in several ways.

1. *Pill-boxes.* Paper from a coil is wrapped around a former, making a cylinder of a thickness depending upon that of the paper and the number of plies. The inside surface of the paper is coated with paste, and thus the joint is made. Such boxes are completed by pushing a disk of paper into the cylinder. The lid is but a shallow box, a trifle larger. Such boxes are also made by coiling a wide sheet of paper on a mandrel in the manner described, and then cutting it into lengths as desired. Lids are made in the same way. Colored boxes are made by an outer ply

of colored paper. Such boxes are also made by machinery. (See Fig. 3516.) In one mode of covering, the strip which is to cover the cylindrical portion has gored margins, which lap over upon the bottom of the box or the top of the lid, as the case may be, and match together.

2. Boxes are made from a roll of paper, which is bent over into shape, cut off, the bottom folded in

Fig. 3516.



Paper Boxes.

against a former, the contacting portions being pasted *in transitu*.

3. Boxes of paper or pasteboard cut from the roll, shaped, and secured by rivets or staples.

4. Boxes made from blanks of the required size and shape, the machine taking them from the pile, shaping and fastening the parts together. See PAPER-BOX MACHINE.

a a' are, respectively, a blank and a box made therefrom, the scale of the latter being enlarged somewhat. With the exception of two slight gores on the edges of the lid-flap, no portion is wasted. Some portions of the box are double and others treble. Parts secured by paste or rivets.

b b' b' show a round box and the metallic fastenings which hold the lapped portions.

c c' are the plan of the pattern and the folded box with a tuck and keeper. *d d'* illustrate another mode of shaping and folding. *e e'* still another, with a lapping lid. *g g'*, a paper box with dovetailing angles. *h h'*, the plan of a blank and the box made from a similar larger blank.

i, a box made from a circular blank, cut on the principle of *i'*, but of larger size.

j j' j'' j''', Heyl's box, whose overlapping pasteboard flaps are secured by rivets.

Seamless paper boxes, lamp-shades, hats, and other hollow articles of paper are made upon formers which are dipped into the pulp; the latter collects on the reticulated surface by means of a partial exhaustion of the air from the interior of the former, the air being withdrawn through an elastic pipe communicating with a bellows or cylinder.

The water being drawn through the perforations, a film of pulp adheres to the surface of the *former*, which is then raised from the vat, and, the coating of paper-pulp being removed and dried, forms a seamless article which requires no farther manipulation for most ordinary purposes, but for ornamental uses may be covered wholly or in part with a second coating of colored pulp, and embossed or otherwise ornamented by stamps, swaging, or perforation. See PAPER-MOLDING.

Pa'per-box Ma-chine'. A machine for making boxes from the roll or from blanks of paper.

Hatfield's machine, March 8, 1870, is designed for attaching the bottoms to cylindrical paper-box bodies previously formed by another machine. The shaft *a* is hollow, and through it works a spindle, operated by means of a hand-lever *c*, and carrying a fixed head or disk.

On the end of the shaft *a* is an expanding head *d*, formed in segments, which are pushed radially outward by links operated by a lever and arm.

f is a tube containing the bottoms of the boxes; these are pressed by the follower *g*, kept in contact therewith by a cord and weight *h*; *i* is a plunger cut-off by which the bottoms are pushed down one by one into contact with the follower *k*. This is advanced by a lever *l* operated by the hand-lever *c* through the medium of the rod *m*; *o* is a treadle connected by cranked arms and rods to the rock-shaft *p* of the lever *l*, and to the arm of a lever having a divided head in which a roller is journaled.

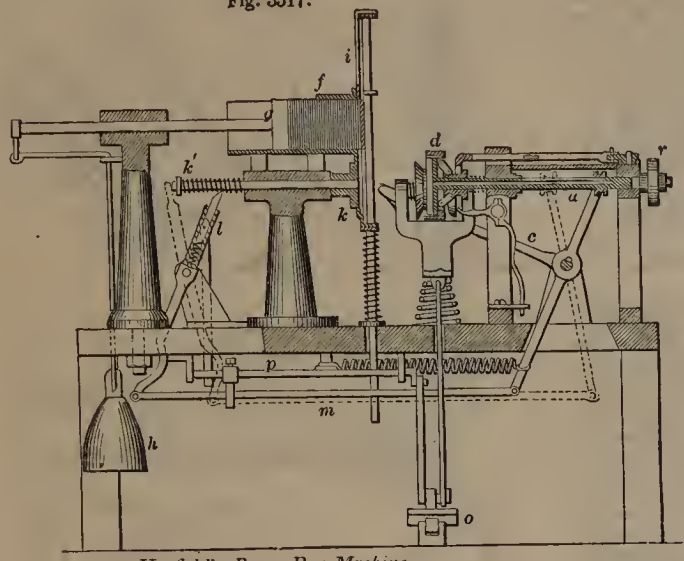
The head *d* is rotated by the pulley *r* on its shaft, and the treadle depressed; this throws the roller out of contact with the expanding head *d*, and also partially rotates the rock-shaft *p*, throwing the latch *l* into position to engage the plunger-rod *k'*. A box-body is slipped over the expanding head, which is then expanded. The lever *c* is depressed, thrusting out the disk within the expanding head and bringing it into position to receive one of the bottoms which has been pushed down by the plunger cut-off *i*. By an upward movement of the lever the box-bottom is pushed into contact with the disk, which, by the same movement, is withdrawn and brings the bottom into contact with the box-body on the expanding head; a slip of prepared paper, pasted on one side, is applied to the junction, the treadle is released, bringing the roller in contact with the side of the box, the rotary movement of which winds the strip around it, where it is fixed by the roller and vibrating fingers on an eccentric.

G. L. Jaeger, February 25, 1873. In this machine, an address or label is imprinted and the box cut out and formed at one continuous operation. The paper passes first between the impression-roller *a* and the type-roller *b*, which is supplied with ink from the trough *c* by inking-rollers *d*.

Circular knives and creasers on the roller *g* cut it into the shape shown on the plan view during its passage between that and the roller *i*. Paste is applied to its edge by the rollers *k l*, in connection with a smaller roller not shown. Proceeding onward, two of the flaps are turned up and secured by pivoted wings *m n*, the other two being similarly treated by other wings, leaving the end flaps to be folded in by hand.

F. Gates, April 5, 1870. For making rectangular boxes. The

Fig. 3517.



Hatfield's Paper-Box Machine.

paper web from the roll *a* passes between the rollers *b c*, by the upper one of which paste from the trough *d* is applied to its edges. It is then carried forward by the feed-rollers *e f*, and the necessary slits cut by a vertically reciprocating cutter, after which it is subjected to the action of a plunger *h*, which shapes it by forcing it within one of a series of molds *i*, on an endless chain *k*, advanced intermittingly by a pawl *l* operated by an oscillating lever from the driving-shaft. The boxes are carried around by the endless chain until they successively arrive in a sufficiently dry condition at a point over an aperture, where they are forced out of the molds by a vertically reciprocating plunger *w*.

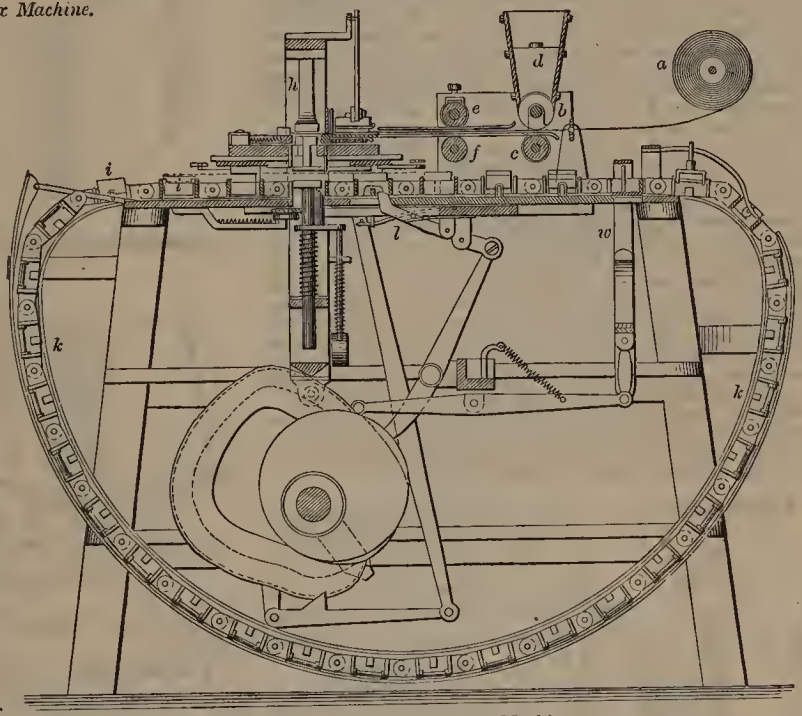
Foster, March 19, 1867. For making match and other tubular boxes. The previously cut blanks are fed upward by a follower, and pushed forward by a reciprocating feed-bar into the flaring mouth of a former, by which the paper is pressed into shape around the head of the feed-bar. It is drawn onward and delivered from the feed-bar by angularly placed rollers, which also turn down and finish the corners. The gumming or pasting is afterward done by hand.

Keating and Waymouth, June 8, 1869. For making and sanding match-boxes. The blanks, cut to shape, are advanced and gummed by means of a roller; each blank as it is gummed is carried forward to a die, through which it is forced by a descending plunger, uniting the gummed edges, and deposited in one of a series of receptacles on an endless conveyer, which carries it forward to a roller by which its bottom is gummed; it thence passes over a box containing sand, a portion of which is deposited on its bottom by a lifter, and is finally discharged by a plunger.

Heyl's patent, October 31, 1871, is for making and covering paper boxes, the flaps being secured by paste.

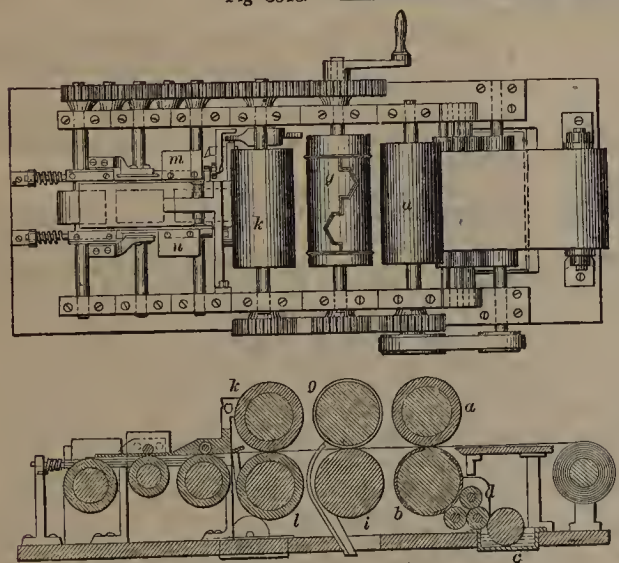
The pieces of pasteboard from which the boxes are to be made are placed directly over the machine in a box, from which they can be dropped one by one at each revolution of the machine, directly behind the crimping-frame or former, and in front of the reciprocating plunger. The plunger then moves forward, pressing the pasteboard through an opening in the *former*, which, being barely large enough to admit of its passage, bends the pasteboard close to the plunger, where it is held

Fig. 3519.



Gates's Paper-Box Machine.

Fig 3518.



Jaeger's Paper-Box Machine.

by a set of nippers attached to the plunger. The plunger then stops its forward movement a short distance in front of the *former* to receive the covering-paper. A strip of paper of sufficient length to go entirely around the box is inserted at the extreme right of the machine, and is caught by and carried around the pasting-wheel, which, in its return motion, transfers the paper to the pressing-wheel, pasted side out; from this wheel it is again transferred to the sides of the box by a forward movement of the pressing-wheel (until it rests against the box) and a revolution of a plunger. The box with the covering-paper around it is then carried forward by the plunger into the folding-frame, when the cover-paper is lapped around against the bottom of the box by a set of leaves or folders which move inward across the bottom as the box is pressed upon them. The plunger then returns to its first position, leaving the box in the folding-frame, which then rocks over into a horizontal position directly under the vertical plunger. The next operation is to fold the upper edge of the cover-paper over the top and down into the inside of the box. This is done by the inward and downward motion of the square-grooved feet of a vertical plunger as they pass down into the box. The label or square piece of paper for the bottom of the box is pasted by being laid upon the paste-roller, from which position it is thrown, pasted side out, up against a platform by a lifting-rack. Small

nippers or fingers attached to the platform grasp the label at either end and hold it against the platform, while the latter turns upward and brings the label immediately under the box. The box is then pushed down through the folding-frame upon the label that lies under it, and the label is made to adhere to the box by a firm pressure of the vertical plunger. This completes the operation, and the vertical plunger returns to its original position, leaving the finished box upon the platform, which in proper time again turns down and casts the box out at the end of the machine.

Patent 132,077 is an improvement on this, and patent 132,076 is a pasting and sanding device for the ends of match-boxes.

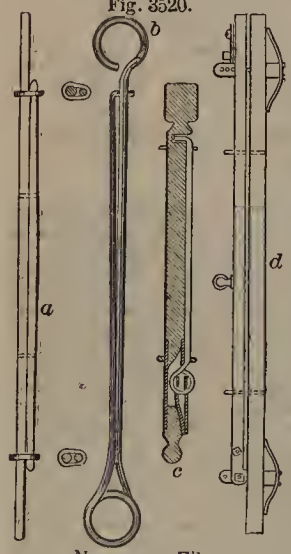
Heyl's patent for making wire-fastened paper boxes, October 8, 1872.

The machine is intended primarily for making boxes of paper or pasteboard without cement, the fastening being effected by wire staples, which are produced and applied by the machine which forms the boxes. The box-blanks are placed in a receptacle provided with a sliding bottom, which is drawn up by a weight and cord applied to a fusee-pulley adapted to graduate the power of the weight to correspond with the number and weight of the blanks remaining in the receptacle. The weight-pulley is detained by a ratchet, which prevents the drawing up of the sliding bottom, excepting when the said ratchet is retracted. The blanks are taken one by one from the top of the pile by a pneumatic or suction feeder provided with automatic valves to adapt it to seize and drop the blanks at the proper moments. The said feeder in its descent retracts the detent-ratchet and receives a slight upward pressure from the pile of blanks. As the feeder rises again with one blank, the detent, being released, catches the weight-pulley, so that, whether the quantity of blanks be greater or less, the top of the pile always rests at one level to receive the feeder. The blank, being deposited on a table by the feeder, is carried forward by a follower to a position over the mold, into which it is forced by a plunger, the bottom flaps being first bent up and the end flaps next folded over them as the plunger descends. The wire to form staples is in continuous lengths, contained on suitable reels, equal in number to the staples used in each box. The lengths of wire are cut off, bent into square form over suitable mandrels, which latter then recede, and the staples are, by sudden percussion, driven through the lapped sides of the box Cavities in the plunger receive the inwardly projecting ends of the staples, which ends are then bent in opposite directions, either toward or away from each other, by slides working in the sides of the plunger. The plunger is then withdrawn, and its descent with a new box discharges that which was previously formed. The various parts are made changeable or adjustable, to adapt them for the manufacture of boxes of various sizes or forms.

Fig 3516 is a view of a box so made, *j* being a sectional perspective view of the box and cover, *j'* a longitudinal section, *j''* a plan of a paper blank adapted for the formation of a box, and *j'''* a plan of a blank adapted to form a cover.

Pa'per-clamp. A device for holding newspapers, sheet music, periodicals, etc., in convenient form for reference, and at the same time preserving them from injury by keeping them clean and flat.

Fig. 3520.



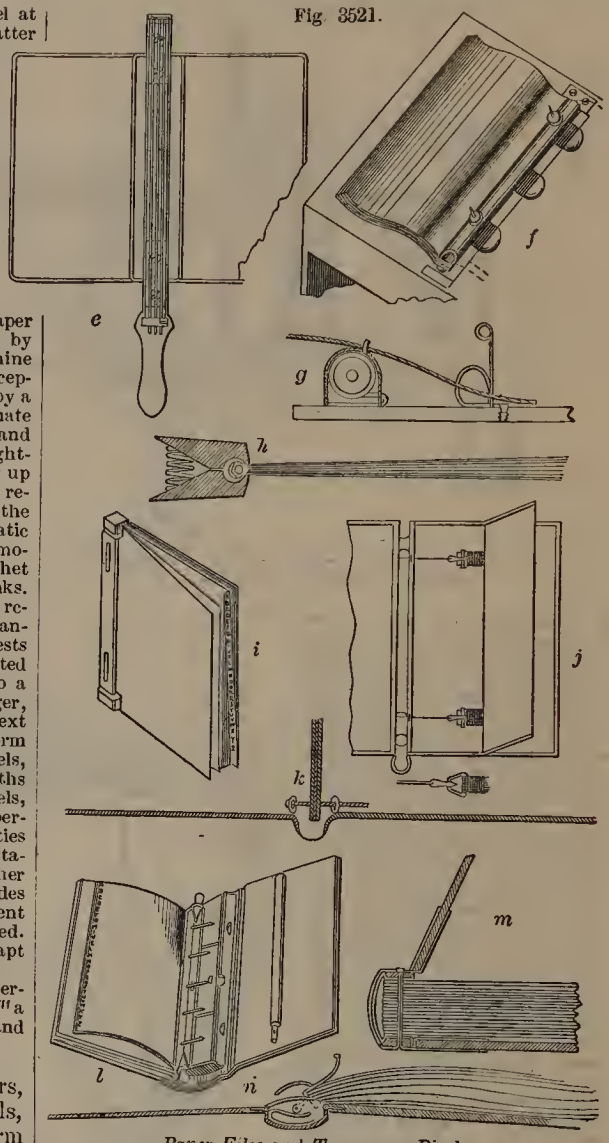
Newspaper-Files.

Of the various forms, some fulfill these conditions very imperfectly, being mainly intended to keep the issues of a newspaper together and keep them from being carried off or dropped upon the floor. Of these there are two kinds, the *portable* and the *desk-clamp*. *a b c d*, Fig. 3520, are portable forms, in which the folding edges of the newspapers are clamped between two bars or wires hinged together.

Fig. 3521 shows several forms, of which *c f g* are intended for desks.

h i j k l m n are all forms of temporary binders, in which the periodicals, papers, or sheet music are held by the folded edge, either by a simple clamp, as in *h i*; by cords, as in *j*; by impaling wires, as in the other figures, which need no lengthy explanation.

Fig 3521.



Paper-Files and Temporary Binders.

Pa'per-clip. A clasp for holding papers together. A means of filing bills, letters, etc. It may be, —

A suspensible hook on which the papers are strung.

A wire on a stand or suspensible, on which the papers are impaled.

A pair of jaws grasping papers, as with the finger and thumb, and intended to lie on the desk or be suspended by a ring.

See also PAPER-CLAMP; PAPER-FILE, etc.

Pa'per Cloth. A fabric patented in England in 1843 by Henry Chapman. It is prepared by winding cotton, linen, or other cloth upon a roller, which is introduced between the third press-felt of a Fourdrinier machine; between this roller and the endless felt is placed a trough containing an adhesive solution, which is, by means of a roller in a trough, applied to the cloth; at the same time, the continuous sheet of paper formed by the machine in the usual manner is carried forward, meeting the cloth, and the two passing together through the pressing-rolls are caused to adhere. By reversing the cloth, a similar paper facing may be given to the other side.

Pa'per Col'lar. One made from paper in imitation of linen. Before the advent of the factitious

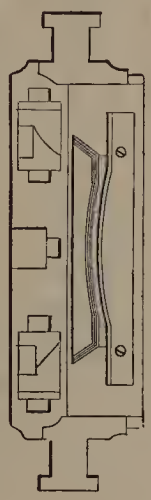
article, made as an object of merchandise and so much worn, collars were occasionally made of paper, either as by Lord Byron, who affected a collar of peculiar shape, somewhat on the sailor pattern, or by mountebanks and wandering minstrels of the colored persuasion. The festive collars of "Brudder Bones" and his partner on the left wing were exaggerated turn-downs or chokers made from cardboard.

The first patent on a collar concerned its shape, and is somewhat curiously described. It was of fabric, and was called the "Belvidera" collar, patent to Cantelo and Kerrison, November 19, 1833.

"The band has a breadth equal to the length of the wearer's neck. Its lower edge is cut curving down in the center, to cover the cricoid cartilage and the thyroid gland, and curving upward on each side to avoid pressing the clavicle and the sternocleido-mastoideus muscle. The upper edge of the band proceeds upward on each side from the center in a line corresponding with the inclination upward of the lower jawbone to a point under the angle thereof, and thence downward at a nearly equal angle, so as to avoid pressure of the mastoid process of the temporal bone. A small oval piece of a size according with the parts to be fitted is cut out of the center of the upper edge of the band, so as to give room for the angle of the thyroid cartilage or pomum Adami."

(Nothing like being precise !)

In 1854, Walter Hunt, after his unsuccessful suit with Howe in the matter of the sewing-machine, confidently asserted to an intimate friend, "I will make a machine which will imprint a stitch more perfect than that of the sewing-machine." The paper collar with an imitation stitch made by an indented tool was the result. Long experiments upon paper, its combinations with cloth and combined fabrics attached by means of paste, followed. The article he put upon the market consisted of thin white cotton muslin, coated upon both sides with a very thin white paper. The face was enameled and polished by calendering. The collar was cut out in several pieces, after the manner of the old cheek-piece standing collar, being in every respect similar, except in material and stitches. The collar was made, like its linen predecessor, in three pieces, united by eyelets, and was fastened by strings. It was coated with colorless, transparent, water-proof varnish.



In 1856, he united two thicknesses of cotton cloth, bleached, sized, and calendered, and fashioned into collars. He was also the first to produce a substitute for the linen collar which had the necessary rigidity, imitation stiffening embossed thereon, and holes punched therein, forming a merchantable article.

In 1857–59, W. E. Lockwood, having purchased the effects of Hunt, added the farther improvement of producing a paper-faced fabric having embossed upon its surface, by means of an electrotype die taken from the fabric itself, an exact imitation of the warp and woof of the fabric, and also of the stitches which constituted its embroidered pattern. This ornamented surface is produced upon all paper collars now in the market. Lockwood also printed fanciful designs on the face of collars, in imitation of calico fabrics.

In 1863, the button-holes, which had formerly been simply punctured, were reinforced by cloth patches by an English maker.

In 1863, Gray of Boston rolled a garrote collar from a single piece of paper, so as to make the standing lappel flare from the neck. He also turned a Byron collar upon a defined curved line, so that the outer portion would have the larger curve, and to avoid puckering the material, and also to provide for the neck-tie.

Evan, in the same year, improved the paper for collars by constructing it of long-fibered stock.

Lang, in 1866, made paper collars and cuffs in imitation of lace.

In the same year, Alden made them of the proper flaring form direct from pulp.

Lockwood, in 1869, embossed coarse cotton sized cloth by means of linen cloth under pressure.

Paper collars are made in several ways : —

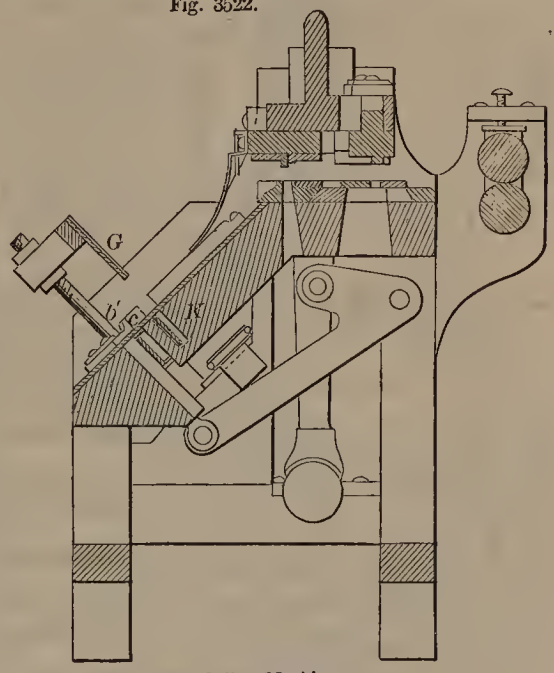
1. They are cut out of piles of sheets, in the same manner as envelopes, by means of a properly shaped knife in a platen press ; the resulting blanks are embossed, button-holed, folded, and curved for the neck by other machines.

2. The collar is cut, button-holed, and creased for folding by passing through a pair of rotary compound cutters and dies.

3. The collar is made by machines which automatically complete the collar for wear from a web of paper. A good example of this is Snow's machine.

Fig. 3522 is a view of Snow's patent of 1865. The paper is intermittingly fed forward by rollers the width of a collar before each descent of the platen,

Fig. 3522.



Snow's Paper-Collar Machine.

which carries, arranged in proper relative position, (1) a set of end knives and end and middle button-hole punches, all adjustable to cut different-sized collars ; (2) a die having serrated teeth to emboss imitation stitches, which is detachable ; and (3) a knife, also adjustable, the front and rear edges of which may be of different curves, for cutting the upper and lower edges of the collar. The bed has corresponding intaglio cutting-dies and a duplicate embossing-die, so as to ornament both sides of the collar. As the ends and button-holes are being cut for one collar, that next in advance is being embossed with stitches, while the forward one is severed from the sheet and slides down the inclined table between end guides until it rests against the stop *b'*. In this position it is struck by the folding-blade *G* and pushed through a slot, resting on a

shelf until it is carried endwise out of the machine by the belt *K* between it and one of the pressing-rolls *c*, which curves it and completes it for wear.

In finishing the blanks, in lieu of several machines performing individual operations, a machine made by Denison carries the blank through the machine, finishing it at successive stages.

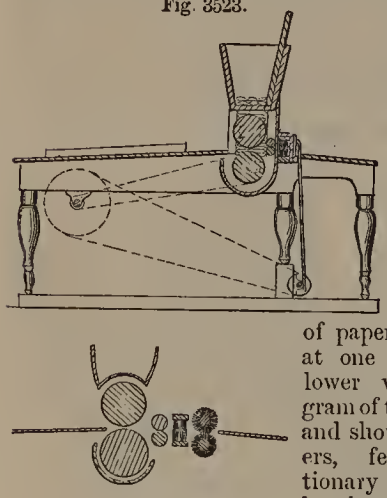
The proper points on the collar are moistened; patches are cut from glutenized cloth strips, and pressed on the moistened spots; through these reinforced points the button-holes are punctured; the crease for folding is indented; the embossed stitching is impressed, and the collars ejected.

At the present time, Denison and Snow have in operation machines which cut the blanks from webs of paper without the slightest loss of stock; while Snow also produces by a novel machine nearly all of the combined cloth and paper used in the collar trade at the present time.

The principal manufactories are at Springfield and Boston, Mass., New York, and Philadelphia.

Pa′per-col′or-ing Ma-chine′. One in which the paper is fed in sheets between color-rollers which give it a coat of color. The example has an upper reservoir for the coloring matter, and another placed below the rollers, so that both sides of a sheet of paper may be colored at one operation. The lower view is a diagram of the moving parts, and shows the color-rollers, feed-rollers, stationary and revolving brushes, and a table, on the right, on which the sheets are received. By disuse of one reservoir the paper will be colored on one side only.

Fig. 3523.



Paper-Coloring Machine.

Pa′per-cut′ter. 1. An ivory blade for cutting paper, the folded edges of uncut books, etc. A *paper-knife.*

2. A machine for cutting the edges of paper in piles. See PAPER-CUTTING MACHINE.

Pa′per-cut′ting Ma-chine′. A machine for cutting paper in piles or in sheets, or for trimming the edges of books, pamphlets, etc.

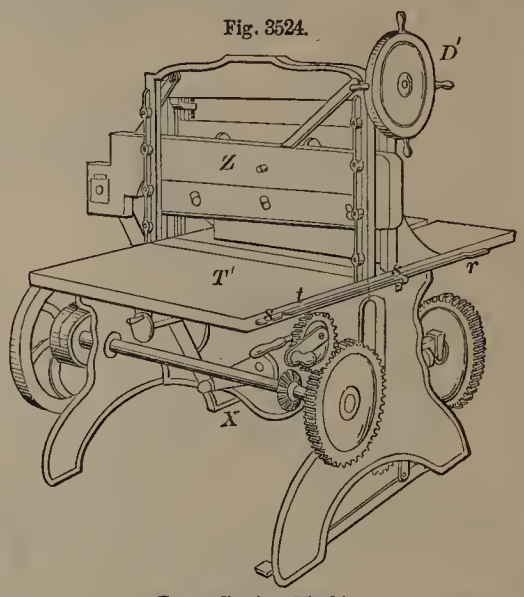
Owing to the sizing and coloring matter, paper is a very difficult substance to cut, and requires a strong knife to pass through any considerable quantity. The knife must also have a draw or shear cut, and requires frequent grinding.

One form of paper-cutter is a straight-edge and traveling knife. Another has a revolving traveling knife sliding on a bar parallel with a stationary knife which acts as one blade of a shears.

Another form has a knife hinged at one end, which descends on a pile of paper with a shear cut. See CARD-CUTTER.

Sanborn's paper-cutter (Fig. 3524) has a cast-iron frame which sustains the horizontal bed *T″* upon which the paper to be cut is placed. Working through vertical slots or guides, formed in the upper part of the frame just mentioned, is the knife-stock *Z*, which carries the knife or cutter, the latter being detachable, so that when required it may be removed for sharpening. The cutter-stock is suspended from a horizontal cross-piece at the top of the frame by means of two toggles or swinging-bars, which, when the cutter-stock is elevated, as shown in the engraving, occupy an inclined position. The cutter-stock is connected by a pitman with a crank arranged underneath the table, and rotated when the apparatus is in use by a belt-wheel operating through a suitable system of gearing, and arranged at one side of the frame; this belt-wheel being furthermore furnished with a suitable balance-wheel. The table is made adjustable under the cutter by suitable appliances worked by a crank, and has a gage *t s r* arranged at one edge and in suitable proximity thereto, so as to guide the attendant or operator in regulating the position of the mass of paper upon the table and in relation to the cutter. The clamp for clamping the paper tightly in place upon the table, previous to and during the descent of the cutter, is operated by appropriate devices, to which movement

Fig. 3524.



Paper-Cutting Machine.

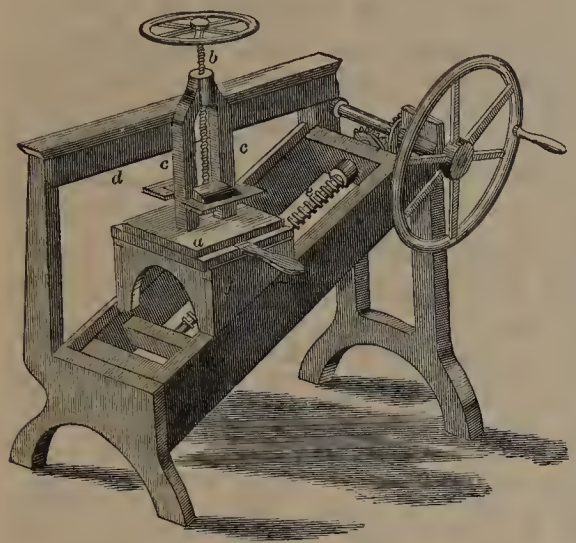
is given by a hand-wheel *D′* arranged at the side of the upper portion of the frame.

The mass of paper having been properly placed upon the table and underneath the cutter, as just above indicated, the driving-belt is shipped to turn the driving-pulley and rotate the crank *X* which operates the cutter-stock. As this latter is drawn longitudinally inward by the action of the pitman, the suspending bars or toggles are brought into a more or less vertical position, thus forcing the stock and its attached cutter downward, and consequently giving a compound downward and longitudinal motion to the same, which insures the gliding cut essential to the perfect working of a machine of this character. As the crank completes its revolution the pitman is of course forced outward, thereby bringing the cutter-stock upward and outward to its original position, preparatory to a repetition of the cutting operation.

Soule's undercut machine has the knife below the bed, and the knife lifts with a shearing cut against a pile of paper held down on the bed by a clamp. The portion of the bed or table outside the knife is attached to the knife-carrier in such manner as to yield sufficiently to receive the part of the paper cut off. The knife moves only far enough to cut through the paper, instead of passing through its whole stroke, as in guillotine machines.

Semple's paper-cutter (Fig. 3525) is used for trimming the folded edges of books and magazines after the sheets are stitched. Two bundles of books are

Fig. 3525.

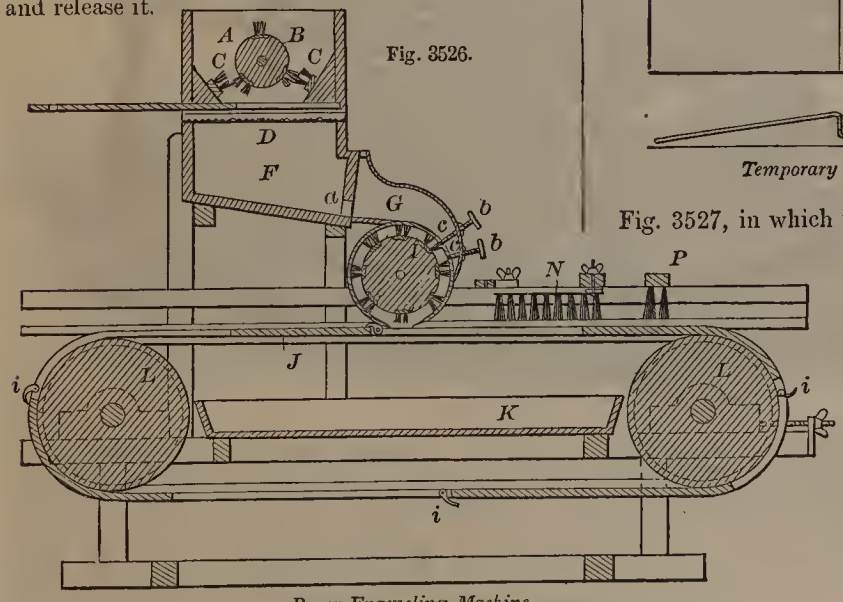


Paper-Cutting Machine.

placed on platform *a* with their backs to the standards *c c*, and are held down by the screw *b*. The platform is then drawn up the inclined track by the action of worm-gear *e*, and the sheets are brought against the knife *d* with a drawing cut. Platform *a* is pivoted to carrier *f*, and revolves to present the top, bottom, and sides of the books to the knife.

Pa'per-en-am'el-ing Ma-chine'. In Fig. 3526, the enameling mixture is thoroughly stirred within the chest *A* by stationary and revolving brushes *B C*; falling through the diaphragm *D* to the chamber *F*, it passes through the gate *a* to the spout *G*, whence it is admitted by the adjustable screw-valves *b c* to the brush-roller *I*, rotating within a cylinder having an opening at its lower side, through which the brushes spread the enamel on the sheet of paper passing along on the endless belt *J*. This is revolved by two cylinders *L L*, having fingers *i i*, which clutch the sheet when presented to them, and after carrying it past the spreaders *N* and blenders *P* fall and release it.

Fig. 3526.



Paper-Enameling Machine.

Pa'per-feed'er. A device for delivering paper singly in sheets to a printing-press, ruling-machine, envelope-cutter, paper box or bag machine, etc.

Sheets are frequently fed to a press or ruling-machine by hand; the pile lies on a feed-board, and the sheets are thrust forward against a guide by a slight blow, the grippers or feed-rollers then seizing the sheet by its edge and carrying it over the guide.

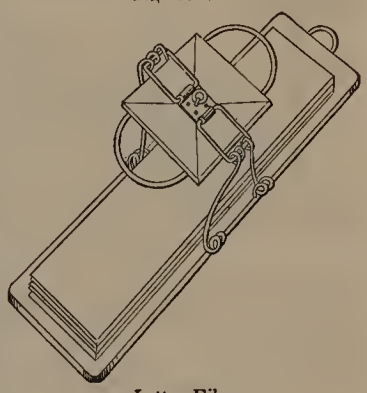
A form of pneumatic feeder has a number of suckers exhausted by an air-pump. The suckers raise the edge of the top sheet, when a puff of air prevents other sheets from following. The edge of the lifted sheet is brought parallel with the grippers, which then carry it to the press.

One form of feeder uses a revolving brush, which sweeps the top sheet from a pile against guides. As the pile diminishes in hight, it is raised by springs underneath.

File-cut fingers to draw a sheet by friction to positive grippers are also used.

Envelope and paper-bag machines sometimes seize their sheets by a gummed roller or claw. The gummed surface of the paper is utilized in the subsequent folding of the parts together.

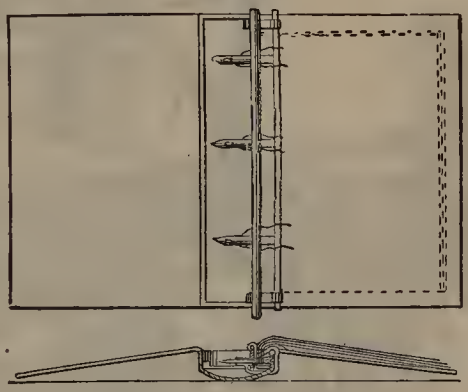
Fig. 3527.



Letter-File.

Pa'per-file. A device to hold letters or other papers in a pack. Among the many forms may be noticed: —

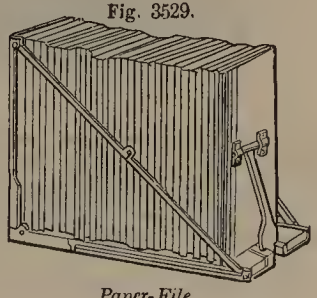
Fig. 3528.



Temporary Binder for Letters.

Fig. 3527, in which the papers are pressed upon a bottom board by a spring follower above.

Fig. 3529.



Paper-File.

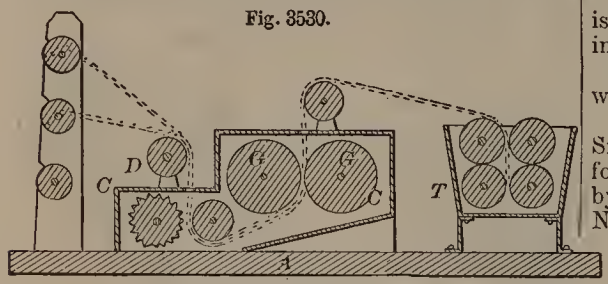
Fig. 3528, in which letters are impaled by their edges and held in a ease or temporary binder.

Fig. 3529, in which the boards of the files are made to fold together, and are held at a right angle when opened, by a pointed brace. The follower is jointed to a bar whose lower end slides and clamps in a longitudinal, under-cut groove. See also PAPER-CLAMP; LETTER-FILE.

Pa'per Floor-cloth. An artificial cloth, used as a substitute for oil-cloth for floor covering and other purposes. It usually consists of a thick sheet or associated sheets of paper treated with paints or varnish.

Fig. 3530 is a machine for converting two sheets of paper into parchment-paper by passing them

Fig. 3530.



Paper Floor-Cloth Machine.

through dilute sulphuric acid and uniting them so as to form a compound sheet suitable for floor coverings, belting, etc. The two webs pass conjointly over the roller *D* to a second roller working against a toothed perforator, which assists in uniting them, this part of the operation being completed by the rollers *G G* in the acid-box *C C*. It is afterward washed by passing between rollers in a water-trough *T*.

Pa'per-fold'er. A bone knife used in folding paper, folding signatures for sewing, and feeding paper from the *bank* to the press.

Pa'per-fold'ing Ma-chine'. A machine for folding printed sheets preparatory to binding.

J. S. Gallaher completed a folding-machine in 1843, deposited a model in the United States Patent Office, and published a description in the Baltimore "Sun." It embodies a vibrating blade, folding a sheet through a slit in the feed-table into the bite of rollers, from which it is carried by endless bands to a second knife between a second set of folding-rollers, and finally deposited in a trough.

Birchall's English patent of 1847 shows mechanism for folding the sheet by a reciprocating knife into folding-rollers.

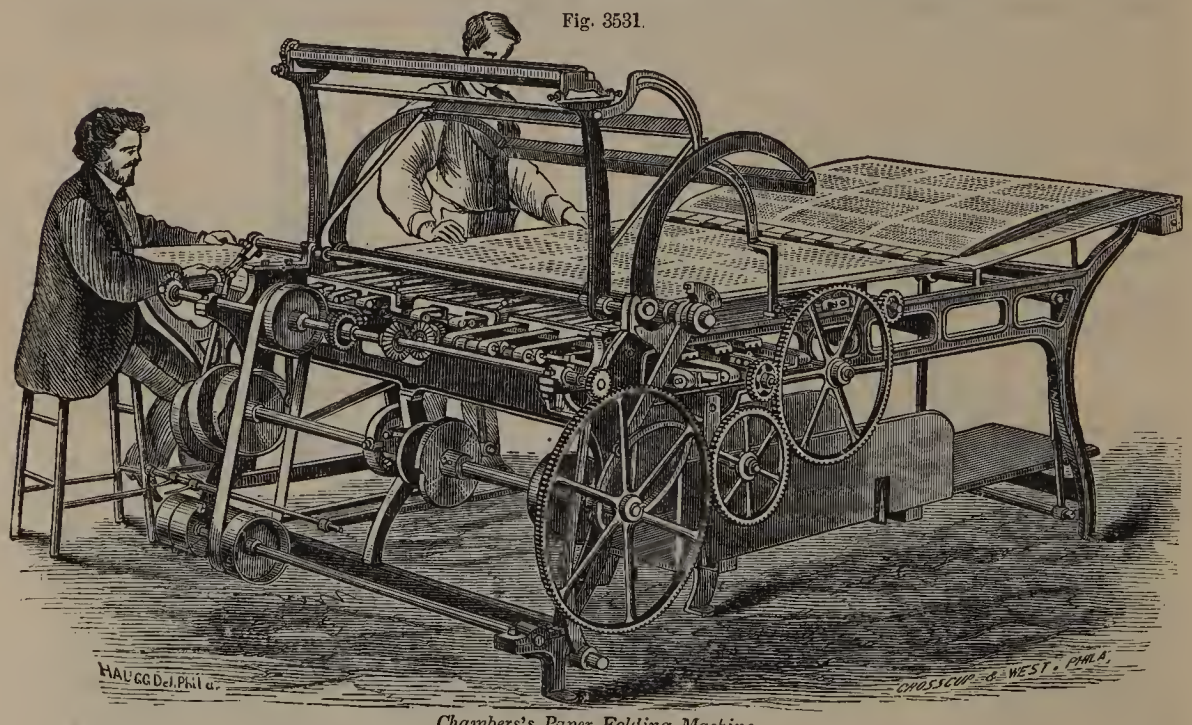
Black (English), 1850, had registering-pins, which were vibrated out of the sheet.

See also Smith's patent, November 27, 1849; Snow, October 15, 1850; English patent No. 13,315, for 1850; North's patent, October 15, 1856; Crosby, December 23, 1856; Smith, May 19, 1857; North, Augnst 10, 1858; Endriss, March 8, 1859.

Chambers, 1856, had registering-pins to fit the perforations made by the printing-press. (See POINT.) These pins or points are adjustable, and, as the folding-blade descends, recede by a cam movement.

Chambers's machine (Fig. 3531) is adapted to fold large double-sheet papers. The sheet to be folded is spread upon the folding-table, and the register secured by points. The folding-blade overhead falls on the middle of the sheet and carries it down, doubled, through a slot in the table. The blade is

Fig. 3531.



Chambers's Paper-Folding Machine.

then withdrawn, and a second fold given the doubled sheet at right angles to the first, by a blade below the bed. The inside sheet is automatically placed in its position, both receive their final fold, and are deposited in a trough under the bed of the machine.

In a machine exhibited at the London Exposition of 1862, the sheets are put singly by a boy under the points of the machine in the same manner as in the printing-machine. A knife moving up and down takes hold of the sheet lengthwise in the center, draws it through a slit in the table, and the first fold is made. The knife returns instantly, and the sheet is taken by a second vertical knife, folding it

at right angles to the first fold. Before the third fold is made the stitching operation commences ; two needles, provided with hooks, passing through the middle of the sheet about an inch distant from each other, draw through the cotton unwound from a bobbin and cut to the required length. The sheet is then folded a third time by a knife acting at right angles with the second one, which takes hold of the sheet and pushes it between a pair of ribbed rollers, whence it passes directly to another pair of polished rollers, and is deposited on the table.

Ford's combination of a folding-machine with a printing-press (1872) is arranged so that the flyer of the press will deposit the papers upon tapes instead of on the ordinary tables, the papers being thence, by and upon the tapes, conveyed to the folding apparatus, and there folded as rapidly as they are printed. See FOLDING-MACHINE.

Pa'per-gage. (*Printing.*) An instrument for measuring the type-face or *measure* of printed matter and the width of margin. It is usually a squared stick on the sides of which are numbered columns of the different sizes of type.

Pa'per-hang'ing. The art of covering walls with decorated paper. The sheet of paper is unrolled, cut to a proper length, the edge trimmed, a coat of paste applied to the back and one end of the piece attached to the upper part of the wall, the lower part hanging suspended thereby ; the workman then lightly dabs the face of the paper with a cloth, commencing at the top and working downwardly until he reaches the bottom, causing its adhesion to the wall and insuring a smooth surface. When the wall has been covered in this way, a narrow slip is pasted around its upper edge, concealing the ends of the pieces and serving for ornament.

The name is derived from the tapestry hangings, for which it forms a substitute.

The art originated in China, where it has been in use from time immemorial. England appears to have been the first European country into which it was introduced; Lanyer, 1634, having obtained a patent for a velvet paper surfaced with a short, dyed, woolen flock, which adhered to figures printed in glue on the paper. This invention was also claimed by several Continental inventors.

Fig. 3532.

Paper-Knife.

Among the kinds of paper-hangings may be cited: —

That simply printed in colors by stencils, blocks, or cylinders.

Flock paper, having a thick covering of woolen stuff, chopped fine and dyed. This adheres to the required portions, which are printed in glue.

Metallic-dust paper, in which flattened specks of metal are caused to adhere to the figures on the paper. See WALL-PAPER.

Pa'per Hot-press. This was invented by Turnbull of England, who adapted the press then used for packing and hot-pressing cloth to the purpose of hot-pressing paper. Noticing the damp and uneven character of the printed work, he placed some circulars between the hot iron plates, and brought down the heavy screws upon them. He then started the business which his descendants retain.

Pa'per-knife. A blade of ivory, mother-of-pearl, or bone, used in cutting leaves of books, folding sheets of paper, etc.

The illustration shows one with an ivory blade riveted to a tang, which is socketed in a vulcanite handle.

Pa'per-mak'ing Ma-chine'. The history of paper is considered under the caption PAPER (which see). The making of paper by machinery commenced near the close of the last century. Previous to this time paper had been made in hand-molds of wire, which molds were made by hand of wires laid parallel and secured at intervals by a fine wire binding. This could be readily made of sufficient size for such sheets as were then required, and the paper of that day shows by its margin the mark of the *deckle*.

The following will indicate the succession and dates of the inventions in the line of paper-making machines. Some collateral points of interest are also noted : —

1750. Woven paper-molds introduced by Baskerville.

1759. The rag-engine introduced into England from Holland, where it was invented about 1750.

1790. The practice of bluing paper is said to have originated about this time from the circumstance of an English paper-maker's wife having accidentally dropped her blue bag into some pulp in an advanced state of preparation.

1798. Louis Robert, a workman in the establishment of Didot, at Essone, France, announced that he had discovered a way of making sheets of paper of large size by machinery.

1799. Paper in an endless web actually made by Robert.

1800. 8,000 francs awarded by the French government to Robert for his invention, and leave granted him to take his working model to England.

1801. John Gamble, an Englishman, who had accompanied L. Didot from Paris with Robert's machine, obtained a patent therefor in England.

Matthias Koops made paper from straw, wood, and other vegetable matters without the addition of other paper stuff. He also discovered a process for extracting ink from old paper.

1803. Bryan Donkin produced a self-acting paper-machine on Robert's plan. He had been employed by Didot and Gamble for this purpose, and appears to have made great improvements on the original.

1804. Henry and Sealy Fourdrinier of London purchased the patents of Didot and Gamble. From the improvements made under their auspices and their manufacture of it on an extensive scale, it received the name of Fourdrinier machine, by which it is generally known.

1805. Donkin altered the position of the cylinders, and by dispensing with the upper web simplified the machine and enabled it to perform a greater amount of work.

1806. Francis Guy of Baltimore obtained a patent for paper carpeting.

1809. The cylinder machine invented by Dickenson, an English paper-maker.

1817. High glazing introduced by Heath ; also English cardboard manufacture.

1819. The London Society of Arts and Manufactures awarded thirty guineas to Mr Finsley for the invention of ivory paper.

1821. T. B. Crompton in England obtained a patent for drying and finishing paper by means of a cloth against heated cylinders, and the application of a pair of shears to cut the paper into suitable lengths as it issued from the machine.

1826. Canson in France applied the system of rarefying the air beneath the web, used in the Dickenson cylinder machine, to the Fourdrinier machine.

1827. Canson invented a method of sizing pulp in the vat, using wax as a basis; Delcambre in the same year employed a size having rosin as a basis; and Obry conceived the plan now generally adopted in France of using rosin and alum dissolved in a solution of soda and combined with potato starch, for the same purpose.

1828. George Dickenson patented an improvement in paper-machines, consisting in giving an up-and-down movement to the paper instead of the shaking lateral movement imparted to the wire web of the Fourdrinier machine, which tended to form longitudinal streaks or ribs in the paper.

A similar contrivance was also introduced by Donkin.

1828. Professor Cowper patented in England a paper-cutting machine which served as a basis for subsequent improvements.

Richard Waterman and G. W. Annis, of Providence, R. I., patented a method for making double paper by bringing a sheet previously formed in contact with the stuff on the belt and passing both between press-rollers ; any number of thicknesses, it was claimed, might be combined in this way.

Crompton and Miller patented a method of cutting an endless web of paper lengthwise by means of revolving blades on a rotary shaft.

Mason Hunting, of Watertown, Mass., patented an improved top press roller, adjustable so as to form paper of any desired thickness by a single operation.

Marsden Haddock of New York obtained a patent for a machine for making paper by dipping, as in the hand-process

1829. W. Dobit, of East Hartford, Conn., patented a machine for cleansing and preparing rags for use in paper-stock.

Isaac Saunderson, of Milton, Mass., patented a horizontal whirl-wheel and sheet-forming rollers in connection with the cylinder machine, to cause a more uniform felting of the fibers,

insure equality of strength in both directions of the paper, and enable thicker papers to be made.

Reuben Fairchild, of Trumbull, Conn., patented an agitator, a semicircular cylinder in the vat vibrating transversely to the making cylinder, for the same purpose.

Thomas Cobb of England patented a method of tinting paper and embossing it during the process of making by passing it between engraved rollers, also surfacing paper with silk, velvet, or other fabric.

1830. A sheet of paper 13,800 feet long and 4 feet wide was manufactured at Whitehall Mill, Derbyshire, England.

Richard Ihotson patented a device for separating from the *stuff* the knots which had passed the strainer. These had previously been picked out by hand.

In England, John Hall patented a mode of introducing water to the vat, by which a considerable pressure was effected on the exterior of the cylinder, causing the pulp to adhere more firmly thereto.

John Wilks added a perforated cylinder to the Fourdrinier machine to facilitate the escape of water from the web previous to its passage through the pressing-rolls; and Dickenson patented a machine for forming a double-web paper by uniting the web in process of formation with a sheet previously formed. Thomas Barratt obtained a patent for a means of impressing the water-mark and maker's name in continuous paper, so as to resemble that made by hand. Thomas and Woodcock, of Brattlehoro', Vt., patented a pulp-dresser; and Thomas Gilpin, of Philadelphia, a paper-calendering apparatus.

1831. J. J. Jaquir obtained a patent for making continuous paper with wire-marks similar to hand-made paper.

Edward Pine, of Troy, and E. N. Fourdrinier patented apparatus for cutting continuous paper into lengths; and Turner, a strainer designed to supersede the agitating vat of the Fourdrinier machine. Carvil, of Manchester, Conn., patented a screen with fans; and John Ames, of Springfield, Mass., introduced a wire cylinder for the purpose of cleansing rags.

1832. James Sawyer, of Newbury, Vt., invented a piston pulp-strainer; John Ames, a sizing-machine.

1852. G. W. Turner, London, England. Improved mode of applying an endless wire-web in a paper-machine; also, mode of passing the paper through a trough of size between two endless felts.

1853. Brown and McIntosh, Aberdeen, Scotland. Hollow perforated mold, covered with felt, to which the pulp is caused to adhere by rarefaction of the contained air.

1853. Machine patented in England for preparing wood for making paper.

1856. Horace W. Peaslee, Malden Bridge, N. Y. Drying cylinder for paper-machines, comprising spiral tubular heater, non-conducting cylinder, and exterior metallic casing.

V. O. Balcom, Bedford, Mass. Revolving pulp-tub with grooved grinding roller rotated therein at a different rate of speed.

Thomas Lindsay and Wm. Geddes of Connecticut. Varying the width of paper while the machine is in operation by forming the trough which delivers pulp to the web in two parts, sliding one over the other and varying the distance apart of the *deckle-straps*.

1859. M. L. Keen, Roger's Ford, Pa. Paper-stock boiler for ligneous matters.

Martin Nixon, Philadelphia. Boiler for treating paper-stock under pressure by the action of upward current of steam and downward current of hot alkaline solution.

Crocker and Marshal, Lawrence, Mass. Combination of drying-cylinders, moistening apparatus, and calender-rolls for finishing paper.

1860. Jordan and Kiney (reissued patent). Conical grinder and case having induction and eduction pipes for rags and size.

C. S. Buchanan, Ballston Spa, N. Y. Rotary boiler with cylindrical concentric strainer and hollow trunnions, for treating paper-stock.

Gelston Sanford, New York. Pulper with conical ribs and serrated rubbers.

A. Randel, New York. Rag-machine with differential rolls, shredding cylinder, and spiked concave.

A. S. Lyman, New York. Separating fibrous matters by subjecting them in a close vessel to the action of an apparatus for beating, rubbing, grinding, or picking, and water at high temperature and pressure.

1863. E. G. Rutledge, Dayton, O. Creating a current in the vat in the direction of the pulp-cylinder.

J. F. Jones. Means for conveying away water from the interior of the *making* cylinders through hollow journals.

John Cowper, England. Rag-mill comprising endless feeder which feeds the material to fluted rollers that deliver it to a toothed rotating cylinder.

J. F. Jones, Rochester, N. Y. Machine by which a number of continuous webs may be made, or they may be united to form pasteboard.

M. L. Keen, Roger's Ford, Pa. Pulp-boiler with perforated diaphragm, discharge pipe and valve for blowing out the contents under pressure.

Ladd and Walsh, New York. Boiler for treating fibers with or without alkali, having a perforated diaphragm for keeping the mass submerged during the process.

The Fourdrinier machine, as improved by Bryan Donkin and subsequent inventors, is illustrated in Fig. 1, Plate XXXVII. That shown, built by George Bertram of Edinburgh, is what is known as an 80-inch machine, that is, the endless web of wire cloth on which the pulp flows is 80 inches wide and 33 feet in length, capable of forming paper over 6 feet wide after trimming the edges, and of indefinite length. The whole machine is about 68 feet long. The operation is as follows: —

Pulp from the beating-cylinder is admitted to the chest *a* through a strainer *b*, consisting of a sheet of metal through which strips are cut; it is here constantly agitated by a stirrer *c*, and is caused to flow into a second and smaller chamber provided with a similar stirrer, which delivers it (after passing over a channeled plate by which extraneous matters of greater specific gravity than the pulp are arrested) on to the endless wire web or apron *d*; to this a shaking movement is imparted, distributing the pulp-fiber evenly over its surface. It is supported on a series of small rollers, and the width of the paper is governed by deckle-straps *e* at each side, which are carried by rollers *f f*, their tension being regulated by the arrangement shown at *g*. *h* is a vacuum-box from which the air is partially exhausted by a set of air-pumps, and which withdraws in part the moisture from the paper as it passes over the box. It is then carried between the cloth-covered rollers *i i*, by the lower one of which and the rollers *j j j* the wire-apron returns to receive a fresh supply of pulp, the paper being transferred to the blanket felt *k*, which conveys it to the press-rolls *l l*; these are solid, and over the upper one is a thin edge-bar, which removes adhering particles of fiber from the roll, and also serves to arrest the progress of the paper should it stick to the roll, thus preventing injury to the blanket. These rolls are adjusted in their bearings by the screw *m*, so as to exert greater or less pressure. The blanket then conveys the sheet to a position where it may be received by the second press-rollers *n n*, which farther compress and expel the moisture from it, and the blanket returns by way of the rollers *o o o* to the point whence it set out. After passing the press-rolls, the paper is received on a second endless blanket, which carries it to the first of a series of steam-heated cylinders, 1 2 3 4 5, between which it is partially dried and conveyed between other pressure-rollers *s*, and thence to a second set of drying-cylinders 6 7 8, whence, after being subjected successively to the pressing and stretching action of the rolls *p p*, it is delivered on to the cylinder or reel *f*. Registering mechanism indicates when a certain quantity has been delivered on to the reel, which is then removed and a fresh one substituted.

The number of drying-cylinders in a machine of this class may be indefinitely increased. In some cases more than 100 are employed, the object being to allow the sizing material to become thoroughly incorporated and to form a product resembling hand-laid paper in quality.

Dickenson's patent of 1847, improvement on patent of 1830, is for an arrangement so that the upper side of the double sheet, that which has not been in contact with the wire grating of the making-cylinder, shall be brought in contact with the metallic press-roll, and in the use of an exhaust-trough between the first and second press-rolls.

In Fig. 2, Plate XXXVII., *a a'* are the two making-cylinders; *b b'*, the couching-rolls. From these the paper is taken by the endless felt *c* to the first press-rolls *d d*, where it is slightly pressed between the felt *c* and another felt *e*, which revolves around the upper press-roll; the paper is then detached from the first felt and led upon another endless felt *f*, which conducts it to the second press-rolls *g g*, where it is farther slightly compressed, and after passing over the guide-rolls *h h* is carried to the third set of rolls *i i*, where a greater pressure is imparted, and thence to the steam-heated cylinders *j j'*, where it is dried and finally wound upon the reel *k*. *l* is the exhaust-trough; it is connected by a pipe with an air-pump, and has rollers for supporting the paper passing over it on longitudinal partitions adjustable to the width of the paper.

In the same patent Dickenson describes a modification of his machine for making triple-webbed paper, the face consisting of a ready-made sheet wound upon a reel to which the others were applied during their joint passage between the press-rolls.

In Scanlan's paper-making machine, the cylinder and Fourdrinier machines are combined for the purpose of making a double-webbed paper. The two webs may be of different texture and color.

In Fig 3, Plate XXXVII.

a a', framework of Fourdrinier machine. *b b*, rollers beneath the wire apron *c*.

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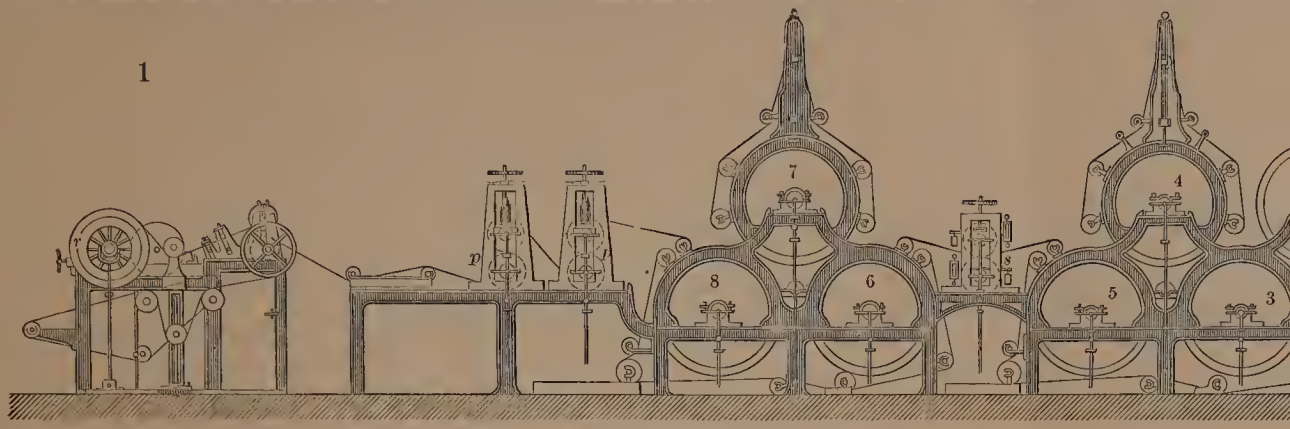
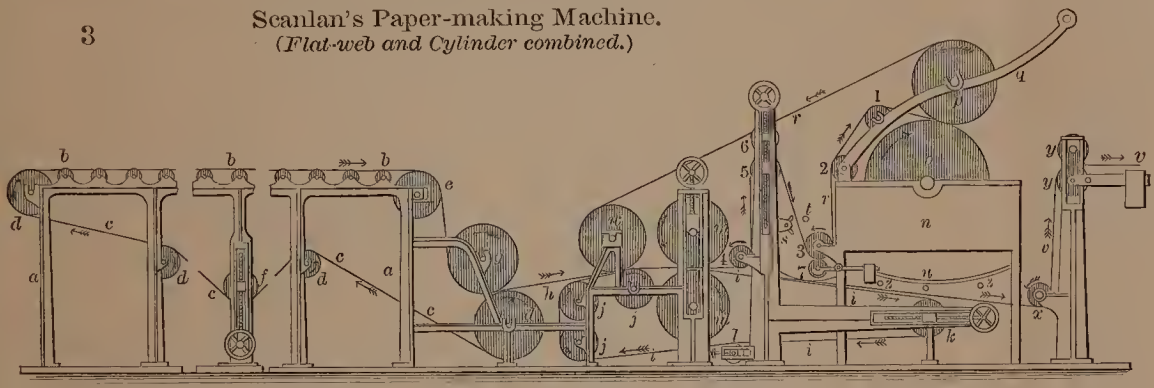


3

Scanlan's Paper-making Machine.
(Flat-web and Cylinder combined.)



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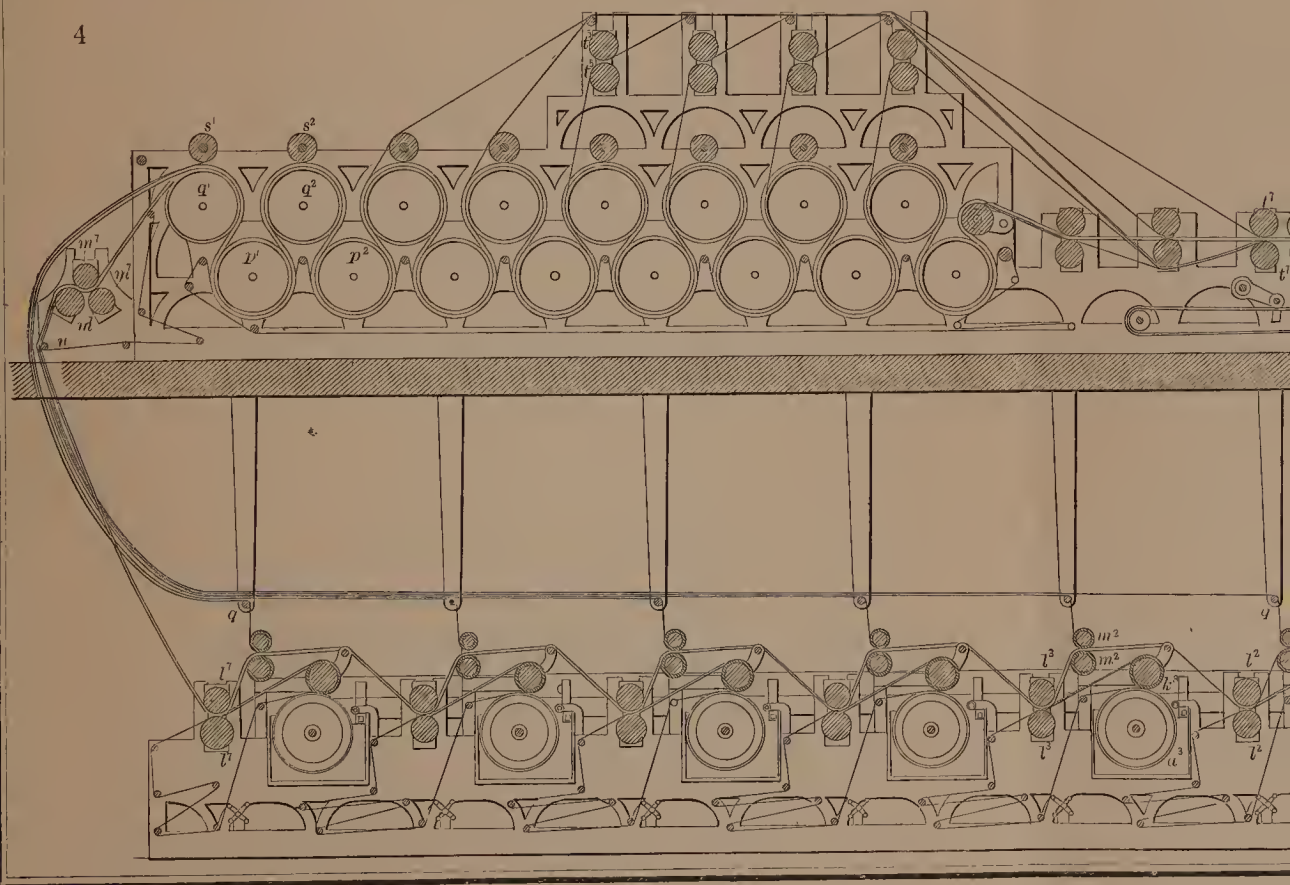
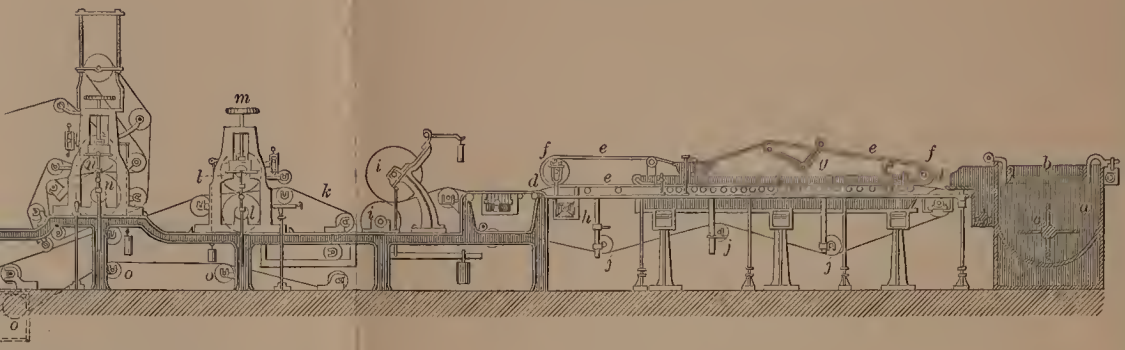


PAPER AND

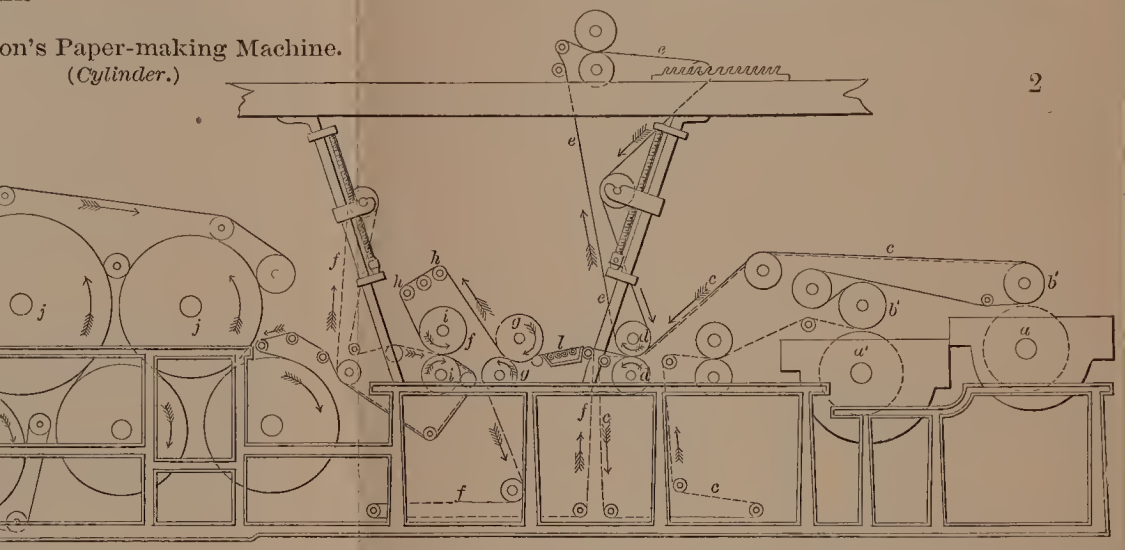
PLATE XXXVII.

Fourdrinier Paper-making Machine.
(Flat web.)

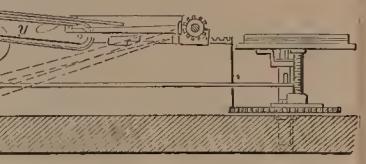


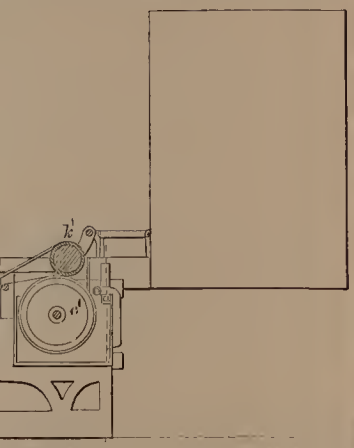
on's Paper-making Machine.
(Cylinder.)

2



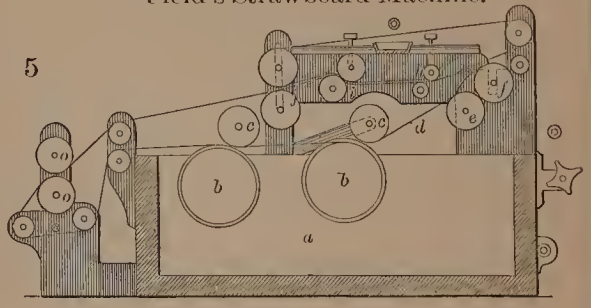
board Machine.
e Cylinders.)





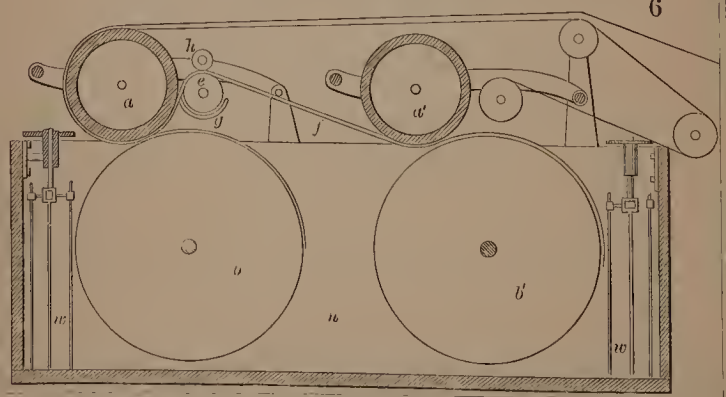
Field's Strawboard Machine.

5



Harris's Double-cylinder Machine.

6



CHINES.

See page 1624.

d d, apron-rollers.
e, guide-roller.
f, tightening-roller.
g, coucher.
h, sheet of paper.
i, first felt.
k, tightening-roller.
l, guide-roller.
m m, first press-rollers.
n, pulp-vat of cylinder-machine.
o, making-cylinder.
p, coucher.
q, coucher-frame.
r, making-felt.
1 2 3 4, making-felt rollers.
5 6, tightening-rollers.
7, squeezing-rollers.
s, felt-washer.
t, shower water-pipe.
u, drip-water guard, heated by steam from *z z*.
v, junction felt
x, guide-roller for sheet.
y y, second pressure-rollers.

The two webs pass from each machine in the direction indicated by the arrows between the rollers *j w*, and are united by the pressing-rollers *m m*, the final pressure being given by the rollers *y y*.

The advantages claimed are that a less quantity of pulp may be used, requiring a less vacuum under the wire apron of the Fourdrinier machine, and causing less strain upon it; that, the backs of the two sheets being united, an equally hard, smooth face may be formed on each side of the paper, and that any defective parts in either sheet are covered by the other.

Either the cylinder or Fourdrinier part of the apparatus may be separately used, if required.

In Jones's pasteboard machine (Fig. 4, Plate XXXVII.) the web formed by the first cylinders at k' passes the rolls $l\ l'$, and first press-rolls $m'\ m'$, and is united between the rolls $l^2\ l^2$ with the web formed by the second pair of cylinders at a^2; the combined web passes through the rolls $m^2\ m^2$, and is united between $l^3\ l^3$ with the third web formed by the cylinders at a^3, and so on, successively taking up the webs formed by each pair of cylinders until the combined sheet passes through the press-rolls $l^7\ l^7$, and is conducted through an opening in the floor above to the press-rolls $m^7\ m^7$, which convey it to the drying-cylinders $p'\ p'$, $p^2\ q^2$ and calendering-rolls $s'\ s^2$, etc., on emerging from which it is carried between the final set of calendering-rolls t^7 to t^7, and thence to a cutting apparatus consisting of a fixed knife and a vertically reciprocating knife working in guides 10, which cut it into sheets. These are delivered singly by an endless band *y* on to a fly which deposits them one by one as fast as cut on a receiving-table. Each of the webs which combine to form the board may, if desired, be kept entirely separate from the others, by winding on the rolls *q q* after passing through its own press-rollers; or the thickness of the board may be varied by connecting together two, three, or more of the webs independently of the rest; or some of the making-cylinders and couchers may be thrown out of action.

Field's machine (Fig. 5, Plate XXXVII.) is of the cylinder class, and an endless wire belt is employed in combination with an endless felt. *a* is the vat, *b b* the making-cylinders, *c c* the couchers. The web passing between the cylinder and coucher is conveyed on the under side of the felt *d* to the squeezing-rolls *e f*, the lower one of which is arranged to the left of the upper, so that the water expressed from the web may not flow back and remove the pulp from the felt. The web, thus partially dried, passes under the wire-cloth and between the pressure-rolls *h i j*; the final pressure being applied by the rolls *o o*.

This invention is particularly designed for manufacturing straw-board and other thick papers.

In Harris's double-cylinder machine (Fig. 6, Plate XXXVII.), the left couching-roller *a* is placed at the left of the making-cylinder *b*, a gauze-covered roll *e* and solid roll *h* receive the single web from the right-hand cylinder *b* and coucher *a'*, from whence it passes by the apron *f* between the left-hand cylinder *b* and coucher *a*, and is united to the web formed thereon.

Vertical agitators *w* are provided at each end of the tank *n*, instead of horizontal agitators between the making-cylinders, as in the common construction.

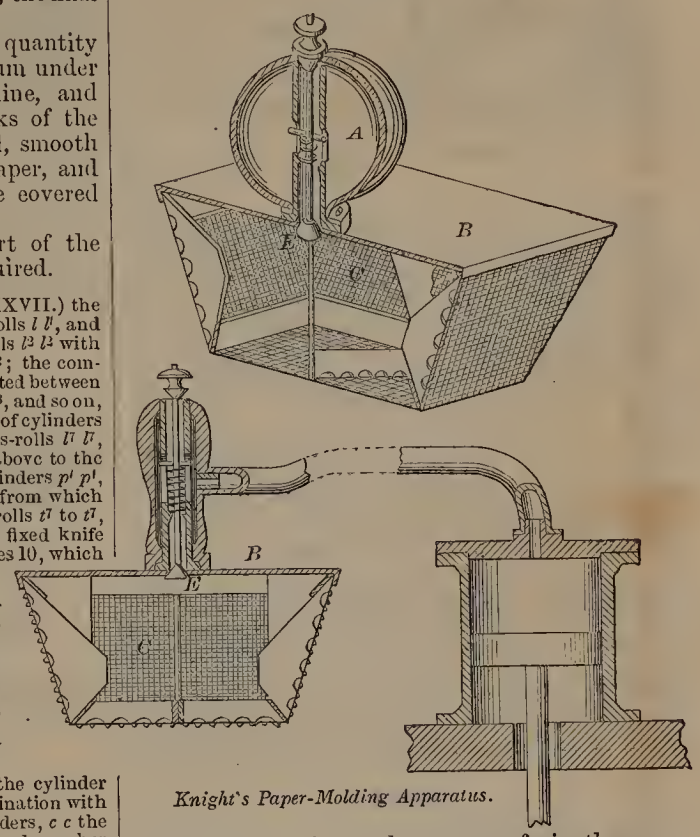
Pa'per-mold'ing Ma-chine'. One in which paper-pulp is molded to the form required, the *shape* being afterward dried. The object is then finished by sizing, varnishing, painting, or what not, according to its purpose.

Brown and Macintosh, English patent 14,131 of 1852, describes a mode of making paper and articles of paper in hollow molds or frames with permeable surfaces, and within which a partial vacuum is obtained. The mold has preferably a covering of felt, upon which the fiber is deposited while the water passes through, and this felt is removed from the *former* with its deposited paper envelope.

See also American patent of French and Frost, 1856; Brown and Smith, 1851; Hatfield, 1862.

Fig. 3533 illustrates the principle of action. A *former* of the shape required — in this case a rectangular lamp-shade — is made of wire-gauze *C* stiffened with internal strengthening plates. The figure shows a mold *B* with a hollow handle, connecting by a flexible tube with an air-pump. The pulp is collected upon the foraminous surface, through which the water passes as the air is exhausted from the interior of the *former*. The sheet of pulp is discharged by the internal pressure of air, the pump being worked as a compressor. The fiber of slightly felted pulp is received from the *former* by a felt cap which fits upon the film, and is from it transferred to a block on which it is dried.

Fig. 3533.



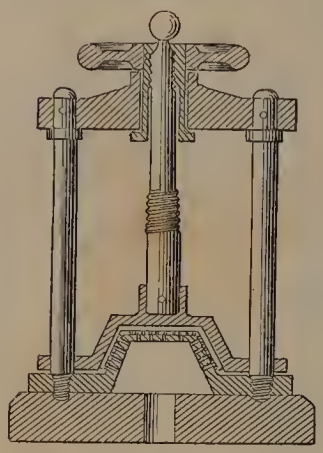
Knight's Paper-Molding Apparatus.

The machine just described depends upon an exhausting air-pump to draw water through the meshes of the wire-gauze which detains the fiber of the pulp, and the thickness of the film of pulp will depend upon the thickness of the pulp and the rapidity and duration of the stream of water passing the wire-gauze. The compression system, in which a quantity of pulp is driven through the meshes of a former on whose surface the fiber collects, has also been repeatedly tried. A third plan is that in which a displacing plunger descends into a molding-former and drives out the water, compacting the pulp against the sides of the *former*.

Fig. 3534 is a machine for pressing and compacting the molded article. The rigid, perforated frame, with the article formed in paper-pulp upon it, is removed and placed beneath a die which expresses the water from the pulp.

In another machine, the blanks are made from paper-pulp in shape suitable for forming boxes, etc. The creases made in the blanks facilitate the bending into form, and the notches in the corners obviate the

Fig. 3534.



Press for Articles of Molded Pulp.

necessity of cutting into shape. See also Kimball's patent, 1868.

In Smith's machine, 1868, the paper-pulp box is made by the sudden descent of a plunger into a perforated mold, which has a permanent perforated lining and removable bottom. The plunger is constructed to automatically admit air beneath its lower end just previous to its withdrawal from the cavity of the completed box or other hollow article. The bottom drops to discharge the molded box.

Leclère's machine, December 8, 1868, is designed for the formation of hollow paper articles from paper-pulp, and operates by employing over a pervious former a column of thin pulp, which in hight several times exceeds the hight of the article to be made.

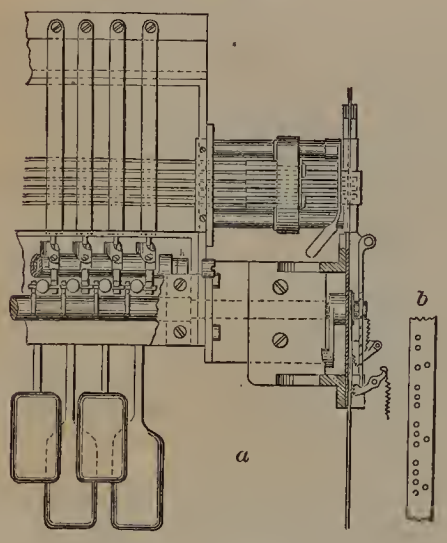
The pulp is condensed on the former and the water expelled therefrom against the atmospheric pressure by covering the pulp-covered *former* with a close vessel, and admitting air under pressure within the *former*. The paper is removed from the cap which received it from the former, and transferred to a receiving block by covering the block with the cap and admitting an air-blast into the latter.

Pa'per-mus'lin. (*Fabric.*) Glazed muslin used for linings, etc.

Pa'per-per'fo-rat'ing Ma-chine'. 1. A machine for perforating paper, as with postage-stamps in sheets, to make a weak line which may enable them to be separated by tearing.

2. (*Telegraphy.*) A machine to perforate strips of paper according to a code, the holes allowing the circuit to be closed, so that the circuit may be made

Fig. 3535.



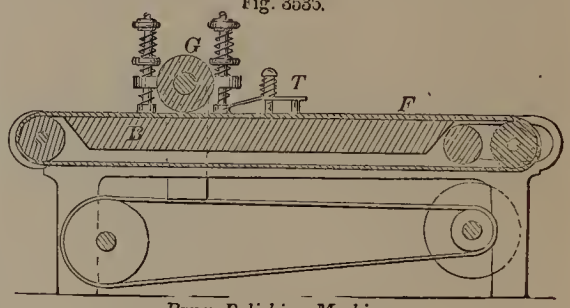
Eddison's Perforating-Machine.

and broken in a given sequence to indicate characters. Eddison's machine for this purpose is shown at Fig. 3535. *a* is the machine; *b*, a portion of a strip perforated for the use of an automatic telegraphing apparatus. A range of finger-keys is provided, and also a range of slide-plates operating upon punches. A presser-lever is connected by a cam with each finger-key, and contiguous thereto are projections upon such of the slide-plates as are to be actuated by the said finger-key; thereby, on striking the finger-key, the proper punches are actuated to punch the perforations necessary for the message complete; and on releasing the finger-key, the paper is drawn along the proper distance by a peculiar feeding mechanism, and the perforations are made in two lines, so that where three or more perforations are placed triangularly, a long pulsation may result from the metallic connection being made through these perforations successively, the contact being made through the second perforation before ceasing through the first, and so on. See also Little's patents, Nos. 91,240, 91,241.

Pa'per-pol'ish-ing Ma-chine'. A machine for surfacing paper by a burnishing action. A fine surface is given to paper by calendering and by pressure between glazed boards or hot plates. See CALENDERING.

In Fig. 3536, the paper is carried on an endless belt *F* of rubber, velvet, or other material, passing over the table *B*. The

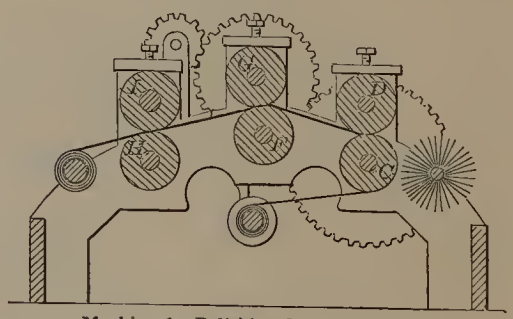
Fig. 3536.



Paper-Polishing Machine.

burnishing-roller *G* rotates in the same direction with the endless belt, but with greater velocity, or it may turn in an

Fig. 3537.



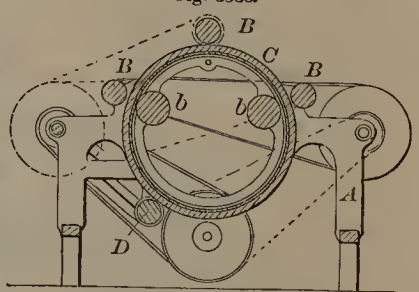
Machine for Polishing Enameled Paper.

opposite direction; it has also an endwise reciprocating movement. A spring presser-plate *T* keeps the paper down to the endless belt, and it or the table is made elastic.

Fig. 3537. The paper passes successively between the rollers *D C F G H I*.

The burnishing-rollers *G I* rotate faster than their fellows *F H*, and *I* has a greater velocity than *G*, so as to exercise a drawing action on the paper.

Fig. 3538.



Paper-Polishing Machine.

Fig. 3538. The hollow annular bed *C* is supported on rollers *b b* within its circumference, and has a reducing roll *D* revolving in contact with it to keep its periphery in true form. The paper is polished by passing between the rolls *B B B* and the hollow cylinder.

Pa′per-punch. An implement for making holes in papers for the purposes of filing, temporary binding, for the reception of eyelets, or for canceling. It is similar to the punches described under the titles of *ticket*, *conductors'*, *spring*, *leather* punches, etc.

Pa′per-rul′ing Ma-chine′. See RULING-MACHINE.

Pa′per-size. Writing-papers are sized with gelatine prepared from tanners', curriers', and parchment-makers' clippings. Plate-paper, when intended to receive impressions in colors, is sized with a clear solution of isinglass. These, or other gelatinous substances, as they impair the tenacity of the semifluid pulp, are applied subsequently to the formation of the paper into sheets or into a continuous roll. For printing papers, a compound of alum and rosin dissolved in a solution of soda and combined with potato-starch is generally used; this is mixed with the paper in the state of pulp.

Starch is also used, either in the form of a paste or as a clear solution.

Pa′per-split′ting. Two pieces of muslin are firmly cemented on the sides of the paper and dried. By a pull on each piece the paper is split open, a portion adhering to each piece of muslin. The halves are then loosened from the fabric by damping.

Pa′per-stock Bleach′er. The machine (Fig. 3539) is intended for expressing the bleaching material from paper-stock, without having recourse to the draining-vat.

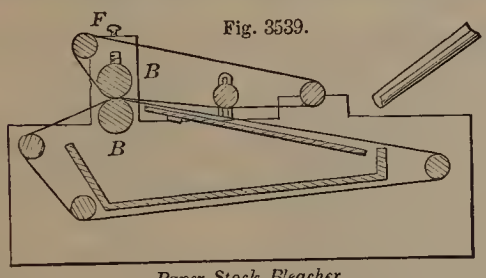


Fig. 3539.

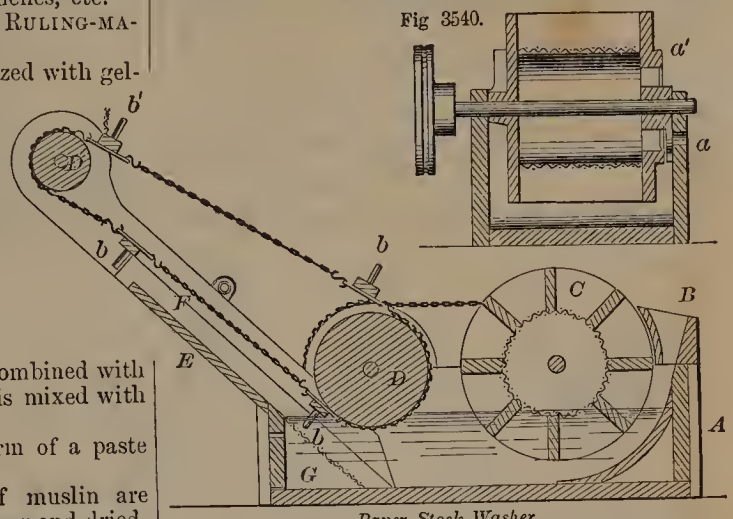
Paper-Stock Bleacher.

The stuff is delivered by a spout upon an endless apron, which is moved and kept tense by a series of revolving rollers, and passes between two rubber-covered rollers *B B*, adjustable to any desired pressure by screws *F*, which squeeze out the bleaching solution.

Pa′per-stock Wash′er. A machine for cleansing shredded rags preparatory to pulping.

The rags are fed into the hopper *B* and are drawn into the tank *A* and agitated by the arms of the wheel *C*. The axis of this wheel is surrounded by a wire-gauze drum, which permits the escape of the dirty water through the annular channel *a′* in the end of the wheel *C* and aperture *a* in the tank, through which a current of water is continually flowing; the cleansed stuff is carried up the incline *E* and delivered at any required point by means of rakes *b b b b′* attached to an endless chain *F*, passing around rollers *D D′*. The rake teeth are so long that they press with some force against the incline *E*, so that when released therefrom they straighten out with considerable energy,

Fig 3540.



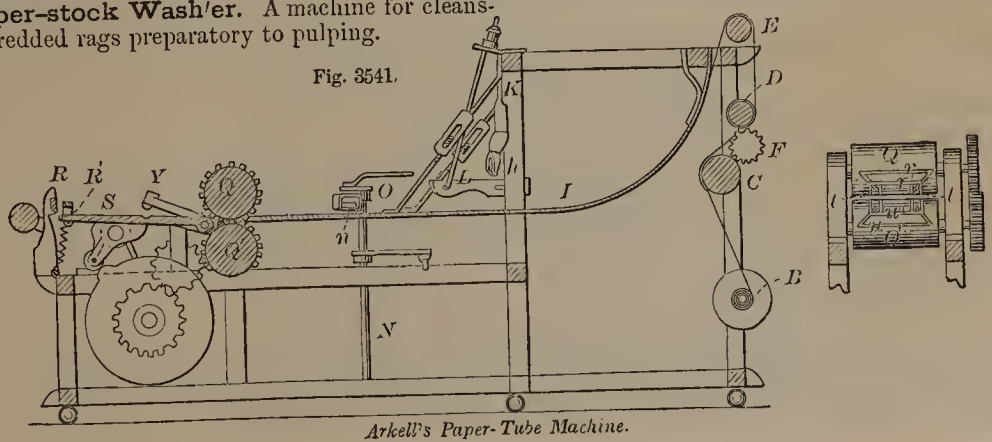
Paper-Stock Washer.

throwing off the stuff. A screen *G* separates gravel or other large particles accidentally intermixed.

Pa′per-tube Ma-chine′. Fig. 3541 illustrates a machine for forming paper-tubes, which are severed into lengths suited for making bags, the bottoms being formed at a subsequent operation.

A continuous roll of paper is wound upon the flanged cylinder *B*, and is thence drawn upwardly on the roll *C*, passing between the furrowed roller *F*, which is partially immersed in a trough containing paste or mucilage, and the rubber-covered roller *D*, by which its edge is pasted; it thence passes over the guide-roller *E*, and is conducted downward along the curved plate *I*, which is concave on its upper side, the concavity gradually increasing as it approaches the blades *L* one on each side; two pressure-rollers *h*, suspended from adjustable bars *K*, serve to hold up the edges of the strip until it is acted on by the blades *L*, which fold the edges over. the folding process being completed by a second pair of blades *n*, attached to adjustable arms *O*. It next passes between the rollers *Q Q′* geared together at one end, the upper one of which has a series of grooves *r r* corresponding to projections *u u* on the lower, which form creases in the tube, while at the same time incisions are made by the cutters *t t* at each side; the pasted edges are thus attached and the bottom shaped. The tube next passes over a loop or guide *Y* attached to pivoted arms by which the tension is regulated as it is presented to the action of the cutters *R R′*: one of these (*R*) is stationary and the other (*R′*) attached to a plate *S*, vibrated by means of a rock-shaft; between the two the tube is cut at the proper points into lengths suitable to form the bag. See also PAPER-BAG MACHINE.

Fig. 3541.

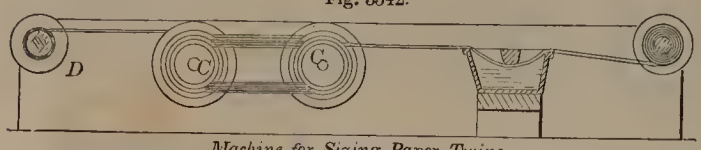


Arkell's Paper-Tube Machine.

Pa′per-twine. A kind of wrapping-twine prepared by twisting a long, continuous strip of paper.

In De Guinon's paper-twine machine, the strip is wound around a central spindle in a shallow circular pan revolving on journals, one of which is hollow and receives a tube through which the strip is drawn, being twisted at the same time by the revolution of the pan.

Fig. 3542.



Machine for Sizing Paper-Twine.

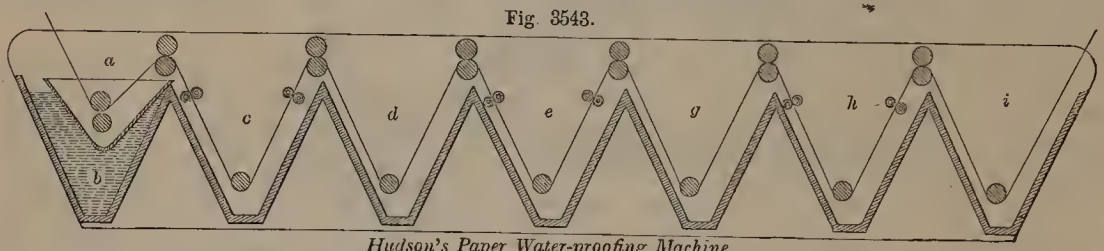
The twine is sometimes sized or varnished. This is effected by drawing it through a pan containing the sizing material. In the machine (Fig. 3542) it is at the same time caused to pass over cone-pulleys *C C*, gradually approaching their larger ends, so as to stretch it, and is then wound upon a reel *D*.

Pa′per Wa′ter-proof′ing Machine′. A machine for impregnating or surfacing paper with a water-resisting material.

Hudson's process of water-proofing paper passes it through a number of troughs containing chemical agents, by which it is acted upon successively.

Fig. 3543 shows a series of tanks used for this purpose. *a* contains a solution of sulphuric acid and water. To maintain this at a proper temperature, — about 60°, — a tank of ice *b* is placed underneath.

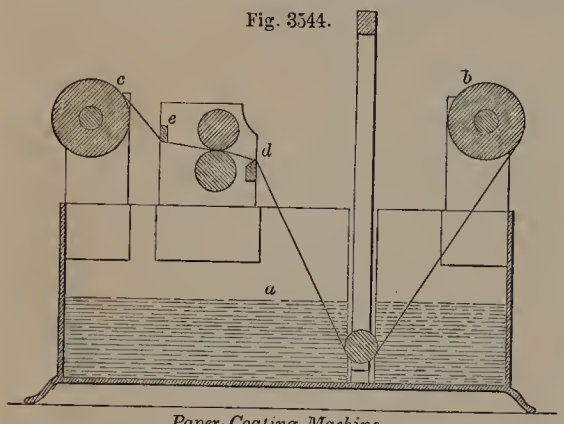
Fig. 3543.



Hudson's Paper Water-proofing Machine.

From the tank *a* the roll of paper is fed over a cylinder, passes between a pair of pressing-rollers, and down into tank *c*, filled with clear water. It then goes over another roller, and down into tank *d*, filled with dilute ammonia. It then passes over another roller, is again pressed, and goes through the vat of water *e*, where it is again washed. *g* contains lime-water, and after the roll of paper has passed through this, and been again washed in *h*, it is finally treated with glycerine in the vat *i*.

Fig. 3544.



Paper-Coating Machine.

A machine for coating paper with tar or asphaltum is shown in Fig. 3544.

a is a tar vat. *b* is a roll of paper, which is fed down into the tar, and is drawn out over the scrapers *d e*, and is wound upon the roll *c*.

Pa′per-weight. Paper-weights are made of various materials, as metal, ornamental stone, or glass. The former two are made by casting or cutting, but the latter, the most beautiful objects of their kind, are formed by arranging a series of small glass tubes of different colors so as to constitute the desired pattern within cavities in a thick disk; a layer of transparent molten glass is then applied, to which they adhere so as to be removable from the disk, after which a second layer of molten glass is applied to the opposite side; the whole is then heated and shaped by means of a moistened wooden concave spatula, and is afterward annealed and polished on the wheel. Figures or portraits made from refractory clay are inclosed in a similar way; but metallic objects, which would be injured by extreme heat, are merely inserted in a properly shaped cavity previously formed in the weight and secured by a cloth glued to its lower surface. See MILLEFIORE-GLASS. See also list under GLASS.

Pa′pier-maché′. A material composed principally of paper, to which other substances may be added to impart special qualities.

The art was probably derived from China. Paper-pulp was combined with gum or China clay by Montin, a German snuff-box maker, who is said to have learned the art from Lefèvre about 1740. In 1745, the year fatal to Lochiel, it was introduced into Birmingham, England.

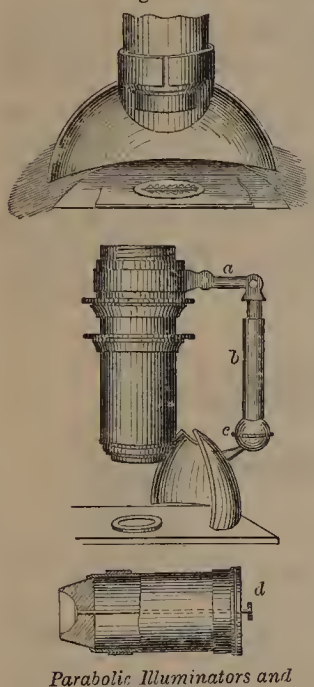
The commoner varieties are prepared by pulping any kind or mixture of different kinds of paper into a homogeneous mass of a doughy consistence. Some earthy material may be mixed with the pulp, as well as chemicals, resinous substances, and glue to harden it and to prevent the attacks of insects. The pulp is rolled into thick sheets, and a sufficient quantity is taken to form the article of ornament desired; this is subjected to heavy pressure between cameo and intaglio dies and afterward dried. Its surface may now be gilt, painted with oil or size colors or varnished. The toughness and lightness of this material peculiarly adapt it for table-ware, table and desk furniture, interior architectural and other ornaments.

The papier-maché used for tea-trays and similar thin articles, which was introduced during the last century, and now forms an important department of industry, is made from sound whole sheets of paper of particular quality, somewhat resembling blotting-paper. These are pasted in successive layers, usually three, upon a metallic mold or pattern, and then dried, the exterior filed to give it a smooth surface, and another layer of three thicknesses applied by pasting; the whole is then again dried, three more sheets pasted on, and the alternate drying and pasting processes thus continued until the required thickness, usually 30 to 40 sheets, is attained. In some cases as many as 120 thicknesses

of paper are employed. The article is now removed from the mold by inserting a knife under its edges, and its surfaces smoothed by the plane, the file, and the knife, after which it is colored and decorated. For this purpose, several coats of shellac-varnish are applied. Japan varnish is used for finishing the surface. This is generally highly polished, the very highest polish, it is said, being imparted by the friction of the hands of women. The final decorations in paint or gilding are in the commoner class of work laid on by stenciling, but in that of the finest quality the artist's brush or pencil is used, with inlaying of mother-of-pearl.

Par-a-bol'ic Il-lu'mi-na'tor. A reflector placed over an object beneath a microscope. Its shape is that of a half-paraboloid, the object being in the focus. The interior is silvered.

Fig. 3545.



Parabolic Illuminators and Reflectors.

Fig. 3545 shows Beck's illuminator with Couch's adaptor, *a b*; this is jointed to admit of free vertical movement, and its lower branch is sleeved so that it may be turned by the thumb-screw *c* to focus the reflector on the object. It is intended especially to illuminate opaque objects.

d is a *parabolic reflector*.

Par-a-bol'ic Re-flect'or. A cone of glass (*d*, Fig. 3545) with a paraboloidal depression which concentrates the illuminating rays upon an object placed in the focus. A small disk mounted on an axial pin forms a dark background behind the semi-translucent object, which is illuminated by an annular pencil of rays passing around the edge of the disk. See SPOT-LENS.

Par'a-cen-te'ri-um. (*Surgical.*) A small trocar for puncturing a dropsical eye.

Par-a-chute'. A device by which a descent is made from a balloon or eminence. It is a light structure, and affords a large area of resistance to the atmosphere.

Loubère, in his account of Siam published 200 years since, describes a machine of this kind used in descending hights.

It was not employed in Europe till 1783, when M. le Normand proved its efficacy by letting himself from the windows of a lofty house in the city of Lyons.

Blanchard, in a balloon ascension in August, 1785, let down a dog from a great hight by means of a parachute, without injury. He afterward applied it to descending from a balloon, in 1793, but, the machine failing to expand fully, he broke his leg in alighting.

The first successful descent by a parachute from a balloon was by Mons. Garnerin, in Paris, October 21, 1797; he descended again September 21, 1802, when on a visit to England for the purpose of practicing aërostation among the islanders. This parachute consisted of thirty-two gores of white canvas, formed like an umbrella of 23 feet diameter; at the top was a round disk of wood, 10 inches in breadth, having a hole in its center to admit short pieces of tape to fasten it to the gores of the canvas. About 4½ feet below the top was a hoop 8 feet in diameter, attached by a string to each seam, and below the hoop the wicker-work car was suspended.

On this occasion, owing to one of the stays giving way, the parachute was caused to "wobble" during its descent, so as to assume a nearly horizontal position at times, and the aëronaut was thrown on his face and injured.

On the 24th of July, 1837, Mr. Cocking ascended in a parachute attached to Mr. Green's balloon for the purpose of making a descent in a machine of his own contriving. It was the reverse of Garnerin's, presenting its convexity downward, like an umbrella reversed, and was no improvement upon the Frenchman's machine. He thought that it would not be subject to the fearful swaying incident to the umbrella form, but would cleave its way directly, and so it did. He miscalculated the amount of resistance, also, and provided his car with a large quantity of ballast. When he detached his parachute, the balloon of Mr. Green ascended at a fearful rate, endangering the fabric; the gas poured down on Green, and might have suffocated him but for the precaution he had taken of having some bags of atmospheric air to support respiration.

Poor Mr. Cocking shot downward, his framework expanded at a bang, breaking some of the cords, which gave it unequal areas of resistance on the respective sides. This made it sway fearfully until some more cords broke, when down he went and was killed upon the spot.

The writer will hazard the prediction that the true form of the parachute will be found in a structure resembling the thistle-seed; a multitude of parts, each light and relatively weak, but opposing an extended and pliable surface to the atmosphere, the resistance of the parachute being the sum of the multitudinous resistances of the gauzy or fibrous portions. The present type seems to be the umbrella, or the pair of wings, — one, subject to destruction if a portion give way; the other, requiring skill in direction and change with varying circumstances and currents of air.

Par-a-chute'-light. A suspended light for use in war to illuminate an enemy's position.

It consists of a large muslin parachute packed in an iron hemisphere, and attached to a second hemisphere containing a light composition. The hemispheres are soldered together. The ball is fired at a high elevation from a mortar, and when the time-fuse explodes the hemispheres are separated, the composition lighted, the parachute expanded, and the light floats along, gradually descending, the flame issuing in a jet below.

Par-a-chute'-light Ball. A combustible ball projected from a mortar to discover an enemy. The heated, evolved gases impinge upon the under surface of the parachute and keep it suspended in the air.

Par'a-close. (*Architecture.*) A screen separating a chapel from the body of a church.

Par'a-dos. (*Fortification.*) A traverse covering the interior of a work from reverse fire.

Par'af-fine. A solid hydrocarbon, crystalline and white at ordinary atmospheric temperatures, discovered by Reichenback, in 1829, in the tar derived from the dry distillation of beechwood. It has since been obtained in large quantities from coal, from bituminous shale, and especially from petroleum, by distillation and rectification by treatment with solution of caustic soda, and subsequently with sulphu-

ric acid. Several oily products analogous in composition but differing in appearance result from these processes, and are used for illuminating or lubricating purposes. The solid paraffine is derived from the densest of these oils; the paraffine crystallizing on standing a length of time. It is farther purified by the centrifugal machine and by treatment under pressure with a small percentage of sulphuric acid. Solid paraffine is employed, either alone or in combination with the fatty acids, for making candles. Its cognate hydrocarbon oils, the various derivatives from petroleum, are well known and largely employed for illumination, etc.

The name is from *parum affinis*, on account of the few substances for which it has an affinity.

The stronger acids, as nitric, sulphuric, or hydrofluoric, the former of which act energetically upon most of the metals and the latter upon glass, exert no destructive action upon paraffine; nor does aqua regia, a mixture of hydrochloric and sulphuric acids, by which gold is readily dissolved. It equally resists the action of alkalies, such as potash and soda, and is therefore adapted and used for the purpose of making joints which shall be impervious to acids and alkalies; for bottle-stoppers, which may be made of solid paraffine, or may consist of corks covered with it; and as a coating for labels and for surfaces exposed to acids or acid fumes. For this purpose it may be simply melted and applied with a brush. It may also be applied in a similar way to paper showbills, etc.; permeating the pores of the paper, it renders it water-proof, and efficiently protects it against the effects of rain.

The process of obtaining paraffine on a large scale from coal or bituminous shale was discovered and patented by James Young about 1850. That employed in the works of Mr. Young at Bathgate and Addiewell, Scotland, is briefly as follows: The shale is broken small in a crusher and then placed in the retorts; these are commonly flattened cylinders of cast-iron, about 12 feet long and contracted toward the ends, which are open, the lower one dipping in a pan of water; heat is applied by a furnace until the middle part of the retort is at a red heat; at a temperature of 300° the hydrocarbons are disengaged in the form of gas, most of which is condensible, and is collected as an oil, which is again distilled and agitated with sulphuric acid in closed vessels, where a black tarry substance resulting from the combination of the acid with the impurities of the oil subsides to the bottom. The clear portion is similarly treated with caustic soda, and again distilled in combination with vitriol and soda, the result being a thin, light, and colorless liquid known as paraffine oil.

Solid paraffine is obtained from the heavier and thicker oil, of which about 20 gallons are derived from each 100 of the crude oil; this is refrigerated by a machine in which a stream of brine is cooled below 32° by a cold-air blast, when the paraffine assumes the solid form.

Par'a-gon. (*Printing.*) A size of type between Great Primer and Double Pica.

Par'a-gran'di-ne. An instrument to avert occurrence of hail-storms. See PARAGRELE.

Par'a-graph. A reference-mark (¶). Also used to indicate a new subject.

Par-a-grele'. A small lightning-conductor set up by means of a pole in French vineyards to aid in drawing off the electricity from the atmosphere over them. The intention is to prevent the occurrence of hail-storms. Arago proposed that the conductors should be raised and supported by small balloons connected by slender wires or chains with the ground. *Paragrandine.*

Par'al-lel. 1. (*Fortification.*) A wide trench parallel to the attacked work, for protecting the besieging troops. The parallels connect the approaches or zigzags by which advances are made on besieged works.

2. (*Printing.*) A reference-mark (‖).

Par'al-lel Bar. (*Steam.*) A rod in the side-lever engine, forming a connection with the pump-rods and studs along the center line of the levers.

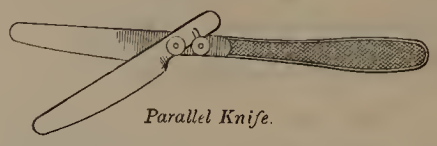
Par'al-lel File. One which has no taper, but preserves its size from tang to point.

One which is flat and strictly correct is known as a *dead-parallel* file.

A round file without taper is a *joint-file;* used for filing the apertures in snuff and musical boxes, hinges, etc., for the reception of *joint-wire.*

Par'al-lel Knife. Two knife-blades in one handle, set *parallel* to each other, with one or more

Fig. 3546

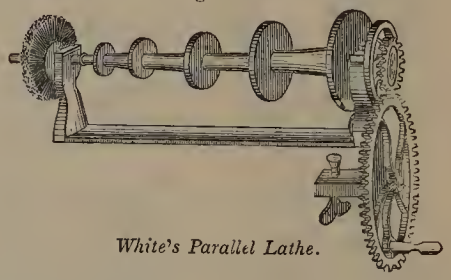


Parallel Knife.

screws to regulate their distance. Used for cutting thin sections for microscopic examination. A *Valentine knife* or *double knife.*

Par'al-lel Lathe. A small bench-tool for dentists', jewelers', and watchmakers' uses. As shown, it is capable of running five corundum stones, a brush, and a drill at the same time. It has a cast-iron frame, with steel spindle and axles, and weighs about eight pounds. It is adjusted to the table or work-bench by a screw-clamp. The collars that retain the grindstones are made of wood, and the

Fig. 3547.



White's Parallel Lathe.

lengths are proportioned according to the requirements of the operator.

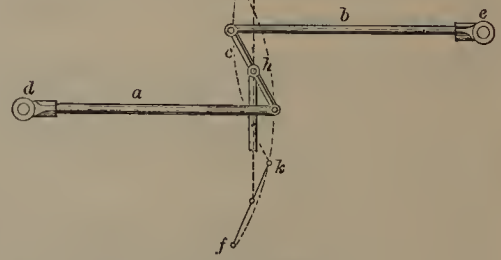
Par'al-lel Mo'tion. (*Steam-engine.*) The device and its name are the invention of James Watt. It is designed to connect the piston and pump rods with the working-beam in such a manner that the former shall move in straight lines.

The principle of the mechanism consists in the fact that in every parallelogram three angles being attached and revolving in arcs of circles, the fourth will continue nearly in a straight line of movement.

Fig. 3548 illustrates Watt's parallel motion.

The equal rods *a b*, connected by the link *c*, are pivoted at *d* and *e*; the piston-rod is connected to the middle point of the rod *c*. During the upward and downward movements of the

Fig. 3548.



Watt's Parallel Motion.

piston, the free ends of the rods *a b* are caused to vibrate in the arcs *f g*, *i k*; one end of the rod *c* being drawn to the left and the other end an equal distance to the right, compelling its middle

point *h*, to which the piston-rod is attached, to reciprocate in a line which does not vary sensibly from a straight one, and which may for all practical purposes be considered such.

Fig. 3549 shows various other devices for causing parallel motion. *A* was used in Watt's original single-acting beam-engines; the piston-rod has a rack gearing with a toothed segment on the beam and working against a roller.

B is commonly used in stationary beam-engines.

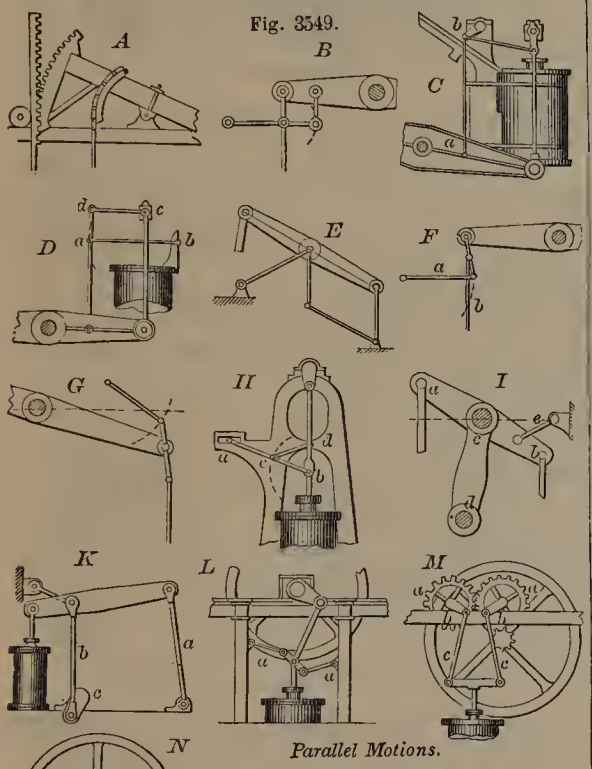
C is used for side-lever marine-engines; the parallel rods from the beam or side-lever *a* are connected with an arm on a rock-shaft *b*.

D, another parallel motion for side-lever engines; *a b* is the radius bar, and *c* the cross-head to which the parallel bar *c d* is attached.

E is used only in some particular cases.

F, the radius rod *a* is connected to the lower end of a short vibrating rod, the upper end of which is connected with the

Fig. 3549.



Parallel Motions.

beam and its center with the piston-rod *b*.

G, a modification of the foregoing in which the radius bar is placed above the beam.

H, one end of the bar *a b* is connected with the piston-rod and the other slides in a slot; the radius bar is pivoted to this bar and the piston-rod, at *c* and *d*.

I, the beam *a b* is pivoted on a vibrating standard *c d*; the radius bar *e* produces the parallel motion.

K, "grasshopper" beam-engine; *a* is a rock-shaft supporting one end of the beam; the shaft *b* is placed as near the cylinder as the crank *c* will work, and in conjunction with the radius bar *d* causes the beam to reciprocate in a vertical line.

L, used in upright engines; *a a* are radius rods connected at one end with the framing and at the other with a vibrating piece at top of the piston-rod.

M, invented by Dr. Cartwright in 1787: the wheels *a a* have equal diameters and numbers of teeth; the cranks *b b* are of equal radius and arc set in opposite directions, keeping the connecting rods *c c* attached to the cross-head of the piston-rod at equal obliquities during its upward and downward movement and causing the piston-rod to move in a straight line.

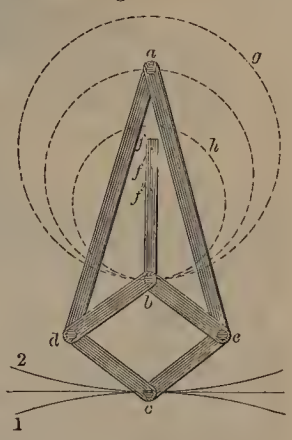
N, the piston-rod *a* is connected with a wrist on the cog-wheel *b*, which turns on a crank pin carried by a plate *c*, which is fast on the shaft; the wheel *b* revolves within a stationary internally toothed gear *a*, of double its diameter, giving motion to the crank-pin, by which means the piston-rod is kept upright.

A very original arrangement for causing a mathematically perfect parallel motion was invented in France, about ten years ago, by M. Peaucellier, an officer of engineers, but has only recently attracted the attention which its importance seems to demand. Professor Sylvester, who first brought it into notice in England, says:—

"It will give to the mechanician unlimited command over the means of transforming motion, and is an instrument that amounts to a new vital element of machinery; perhaps the most important additiou to it since Archimedes's invention of the screw, about 250 [236] years B. C.; one that raises the theory of link-work to the dignity of a calculus, that enables the algebraist to fashiou and write out in his study, by the rules of his science, a working plan for compelling a system to perform some of the most complicated movements that can be required for any purposes of the useful arts in their most refined and varied applications."

It consists of six pieces, *a d*, *a e*, *b d*, *b e*, *d c*, *e c*, jointed together, as shown in Fig. 3550. At *a* is the fulcrum on which the apparatus turns. *b* is the point at which power is applied, and *c* the point at which it acts. At *b* a rod *b f* is attached to the rhomb *d b e c*, and this may be pivoted at any portion of its length; if pivoted at a point *f*, less than half-way between *a* and *b*, and power be applied at the point *b*, this will describe an arc of the circle *g*, exterior to *a*, while the point *c* will follow a curve 1 convex toward *a*; on the other hand, if the pivoted point be at *f''*, the point *b* will move in an arc of the circle *h* interior to *a*, and the point *c* will describe a curve 2 concave toward *a*. When, however, the arm *f b* is pivoted at a point *f'*, midway between *a* and *b*, the arc traversed by *b* will of course form part of a circle whose circumference passes through *a*, while the point *c* will move, not in a line approximately straight, as the head of the piston-rod does under the operation of the parallel motion of Watt, but in a mathematically straight line.

Fig. 3550.



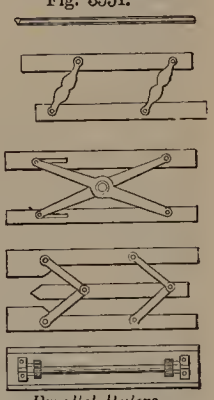
Peaucellier's Parallel Motion.

By varying the position of the pivotal point the point *c* may be caused to describe an infinite number of curves either concave or convex toward *a*.

By an amplification of the parts other curves may be described, as parabolas, hyperbolas, and other conic sections.

Par'al-lel Rul'er. A draftsman's instrument, consisting of two wooden or metallic blades, so joined together by jointed cross-pieces as to open to different intervals and yet retain their parallelism.

Fig. 3551.



Parallel Rulers.

A still simpler form is a rolling cylinder *a*.

b is the ordinary form of two-leafed ruler with two links.

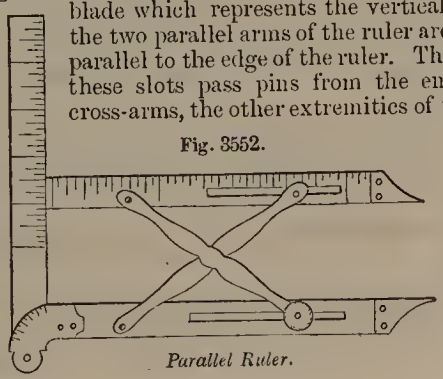
c is a two-leafed ruler with cross links.

d is a three-leafed ruler, the middle section being united by links to the main sections.

e is a flat ruler with a pair of grooved wheels, fixed on an axis, rotating in bearing-posts fastened to the ruler.

Fig. 3552 is a form of ruler having a graduated ruling-blade moving in contact with a graduated blade which represents the vertical. In the two parallel arms of the ruler are slots parallel to the edge of the ruler. Through these slots pass pins from the ends of cross-arms, the other extremities of which

Fig. 3552.

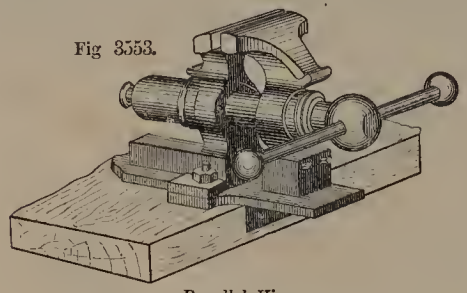


Parallel Ruler.

are pivoted to the two parts of the ruler; distances apart of the bars are measured on the vertical bar.

Par'al-lel Vise. A vise whose jaws move in exact parallelism, a bar on one slipping in a socket in the other; in contradistinction to the kind in

Fig 3553.



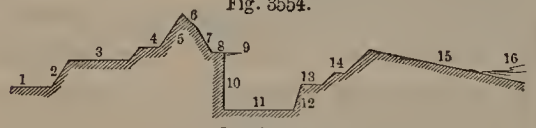
Parallel Vise.

which the shank of one jaw is pivoted to that of the other and moves in an arc of a circle.

Par'a-mat'ta. (*Fabric.*) A light twilled goods having a cotton warp and a merino-wool weft. *Paramatta cloth.*

Par'a-pet. 1. (*Fortification.*) A breast-high defense of earth or stone around a work for shielding troops from the enemy's fire. It is so formed that the earth of the excavation (*déblai*) is sufficient for the ramparts and parapets (*remblai*). Inside is the body of the place; outside are the ditch, glacis, etc.

Fig. 3554.



Earthwork.

1, interior.
2, interior slope.
3, terre-plein.
4, banquette.
5, parapet.
6, superior slope.
7, exterior slope.
8, berme.
9, fraize.
10, scarp or revetment.
11, ditch.
12, counterscarp.
13, covered way.
14, banquette of the glacis.
15, glacis.
16, abattis.

2. (*Architecture.*) A wall carried up on the brink of a quay, bridge, or house-top.

Par'a-sol. A sunshade, usually smaller than the *parapline* or umbrella (which see).

Parasols and feather fans, large enough for sunshades were carried by attendants, and are shown in the ruins of Egypt, Persepolis, Nimroud (*Nineveh*).

Sylax, an ancient historian, asserted that there dwelt in India countrymen with feet of so large a size that they used them for parasols. (Philostratus.) Herodotus rejected the *yarn*, as also the statement repeated by Strabo, that the ears of some of these Indians were like winnowing-fans, and that they wrapped themselves in them to sleep.

The Chinese invented the folding parasol or umbrella. Their modern use dates from 1820, and their present form is said to have been devised by the Duchess of Rutland. The Chinese paper-parasols, called *kittysols*, are now largely exported. The gift of a parasol is said to be a mark of kingly favor in China.

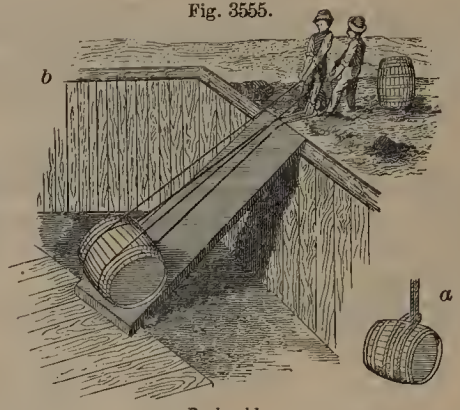
"Artaxerxes gave to Entimus, the Gortinian, a couch with silver feet, and cushions for it, and a flowered tent surmounted with a canopy, and a silver chain, and a gilt parasol, and vessels of gold and silver, and 100 girls and 100 boys," etc. — ATHENÆUS.

Par'a-ton-nerre'. (*French.*) A lightning-conductor. See LIGHTNING-ARRESTER; LIGHTNING-ROD.

Par'buck-le. A double sling *a* made of a single rope, for hoisting or lowering a cask or gun.

A means for raising or lowering (*b*). The bight of

Fig. 3555.



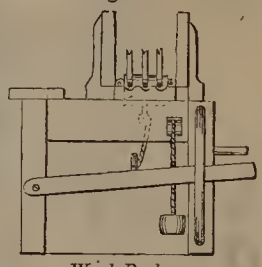
Parbuckle.

the rope is placed round a post; the cask, spar, or gun lies in the double loop.

This plan is adopted in Captain Cunningham's mode of furling sails by rolling the yard. The latter lies in the bight of the chain, and is rolled as it is raised or lowered, the yard-arms resting in hoops slung from the *lifts*.

Par'cel. (*Nautical.*) A wrapping of tarred canvas on a rope to prevent chafing. It is cut in long, narrow strips, well tarred, and made up into rolls before commencing to lay it on the rope. Usually, the rope is *wormed*, then *parceled*, and then *served*. See under those heads.

Fig. 3556.



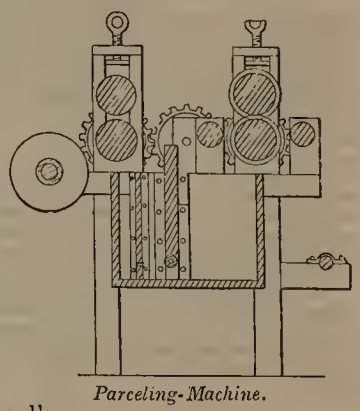
Wool-Packer.

Par'cel-ing-ma-chine'. 1. A press in which yarn, cloth, or wool, etc., is bundled up compactly for tying. See BUNDLING-PRESS, page 405; FLEECE-TYER; WOOL-PACKER, etc.

The example is a machine for bundling and tying fleeces. The fleece is laid upon the table, the slotted belt brought over it and attached to the treadle-lever, whose depression draws the belt and brings up the twine-carrying fingers through the slots in the belt and over the fleece.

2. A machine in which strips of canvas or cloth are dipped preparatory to wrapping around ropes or cables.

Fig. 3557.



Parceling-Machine.

The example is for the manufacture of parceling or tarred canvas covering for ropes, seams, etc., in vessels. The machine consists of cutting and drawing and pressure rolls, in combination with an interposed tank for the tar in which the material is immersed, and bobbins or spools upon which the prepared canvas is wound in rolls.

Parch'ment. Fine parchment is manufactured from the skins of young calves, kids, lambs; also from sheep and goat skins. Extra fine, thin parchments are made from the skins of still-born lambs, kids, and calves.

Coarse parchment for drum-heads, etc., is made

from calves', wolves', asses', and he-goat skins. The ass's skin is said to be remarkably sonorous, and it is no wonder, seeing the amount of noise it has contained at various times. The Greeks found the bones of the ass to be a superior article for making flutes. The flute and drum, a rich asinine combination, which probably suggested the bagpipe, whose drone is the nearest to the paternal blare of anything artificial.

After removing the wool, the skin is steeped in lime and then stretched in a wooden frame; its face is then scraped with a half-round knife. The next process consists in rubbing the skin, previously sprinkled with powdered chalk or slacked lime, and scraping it with a knife. It is then rubbed with a lamb-skin having the wool on, to smooth the surface and raise a very fine nap; after which, if any greasy matter remains, it is again steeped in the lime-pit for a few days. The grain surface is then removed with a knife and the skin pumiced, if necessary, to give it an equal thickness.

In coloring parchment, a green color may be given by spreading with a brush a solution made with crystallized acetate of copper, 30 parts; bitartrate of potassa, 8 parts; rain-water, 500 parts; nitric acid, 4, added when cold.

The substance is said to have been invented by Eumenes, king of Pergamus, as a substitute for papyrus, on which an embargo was laid by Ptolemy Epiphanes as Eumenes was collecting a library in emulation of the famous one in Alexandria. After the library in the Bruchion was burned, during the siege of Alexandria by Julius Cæsar, Marc Antony presented to Cleopatra the rival library of Pergamus, consisting of 200,000 volumes (*volumen*, a scroll). It was subsequently destroyed, the Saracens burning what Theodosius had left. See PAPER.

Parch'ment-pa'per. Made by immersing ordinary unsized paper in sulphuric acid, diluted with about half its volume of water. It is withdrawn in a few moments, and on drying is found to have assumed a new character, resembling rather that of animal membrane than vegetable fiber, and its strength is nearly doubled. After the immersion it is washed in water, afterward in dilute ammonia, and if any of the latter remains it is removed by lime or baryta.

It was invented and patented in England by Mr. Gaine. Figuer and Pomarede made attempts in the same direction in France, 1846.

Karchiski, in 1860, subsequently treated the paper with glycerine, to give it suppleness. Stuart Gwynne made fractional currency of it about 1865 or 1866.

To avoid the imperfect penetration of the acid, J. J. Ott treated a number of thin sheets with the acidulous solution, and combined them into a homogeneous sheet.

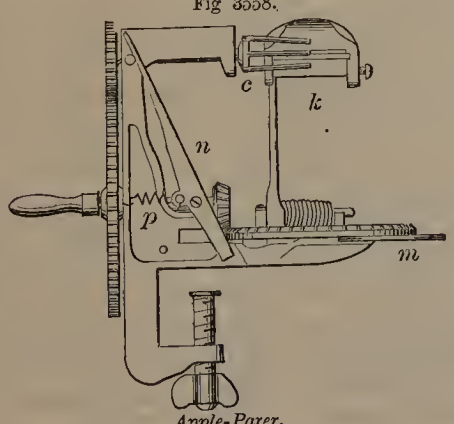
A. T. Schmidt added the glycerine to the acid.

Thomas Taylor (England, 1869; United States, 1871) treated the paper with chloride of zinc. See,—

Hudson, March 16, 1869.
Hudson, September 27, 1870, two patents.
Sheldon, January 25, 1870.
Schmidt, April 4, 1871.
Hanna, October 31, 1871.

Par'close. (*Nautical.*) The limber-hole.

Fig 3558.

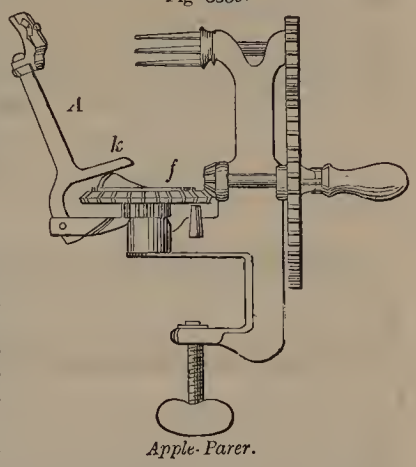


Apple-Parer.

Pa-ren'the-sis. A mark consisting of two curved lines face to face ( ). They inclose matter which is cognate to the subject, but which may be omitted without impairing the grammatical construction or the substantial meaning.

Par'er. In Fig. 3558, the apple, fixed on the rotary fork *c*, is pared by the knife *k*, also rotated by bevel gearing. When the knife makes a revolution, completing the paring operation, a projection *m* on the horizontal bevel-wheel strikes the foot of the pivoted lever *n*, throwing its upper end forward so as to push the apple from the fork. The lever is then brought back to place by a spring *p*.

Fig 3559.



Apple-Parer.

In the apple-parer (Fig. 3559) the cutter is carried on an upright *A*, pivoted at bottom, having a projecting arm *k*, which is once during each revolution struck by an inclined cam on the upper side of the bevel-wheel *f*, causing it to make a partial revolution, and throwing the knife back so that the apple may be readily removed from the fork.

Par'get. (*Plastering.*) *a.* A plaster formed of lime, sand, hair, and cow-dung, for lining the interior of flues. *Pargeting.*

b. A plaster-work executed in raised ornamental figures, molded or impressed by the trowel.

c. A stucco.

Pa'ri-an. (*Pottery.*) A variety of porcelain having the appearance of Carrara marble, and made by the substitution of soft feldspar for Cornish stone in the porcelain process.

It derives its name from the celebrated marble of Paros, and is much employed for statuettes and other works of art.

It is composed of about ⅔ silica and nearly ⅓ alumina, with a small proportion of soda, potash, lime, magnesia, and iron. These are finely ground and thoroughly mixed to a creamy consistence. The fluid is poured into a mold and afterward baked. Some of the articles made by this process consist of many pieces which require to be joined together. The inequalities of the joints are then obliterated and the work baked and annealed.

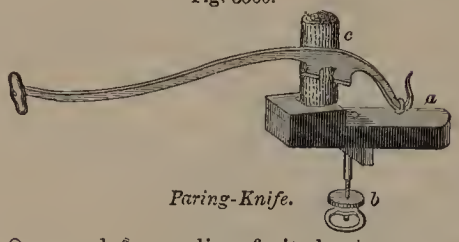
Par'ing. (*Bookbinding.*) Thinning the leather toward its edge so as to prevent a square projection at its terminating edge.

Par'ing-chis'el. A joiner's chisel having the basil on one side, used in fitting and finishing; not differing essentially from a *firmer*. Its name is derived from its being used by hand, with a paring action, in contradistinction to the *socket* and the *mortise* chisels, which are adapted for the mallet.

It is usually longer in the blade than a *firmer*-chisel and lighter than a *mortise*-chisel.

Par'ing-knife. 1. A knife used by wood-turners and others for roughing out work; it has a hook at one end passing through an eye-bolt in the block *a*, allowing considerable freedom of motion; the block is secured to a lathe or work-bench by screw attachment *b*; *c* is a piece of wood being pared.

Fig. 3560.



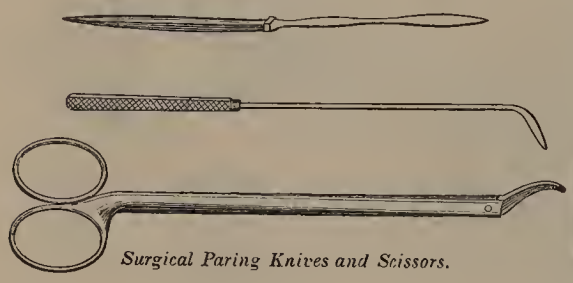
Paring-Knife.

2. One used for peeling fruit, having a guard to regulate the depth of cut.

3. A farrier's hoof-paring tool.

4. (*Surgical.*) A knife used in removing the cuticle or ragged edges of parts which are to be placed in apposition that they may grow together.

Fig. 3561.



Surgical Paring Knives and Scissors.

The examples are respectively, —

Upper one, Sim's knife for paring edges in the operation of vesico-vaginal-fistula.

Below it, curved knife for same operation and that of cleft palate.

Par'ing-ma-chine'. A key-grooving machine.

Par'ing-plow. (*Husbandry.*) A plow for cutting sods or turfs from the surface of the ground. A *sod-plow.*

Par'ing-scis'sors. (*Surgical.*) A scissors for trimming the edges of wounds, or freshening the edges of fistulous openings, in order that they may grow together when brought into apposition and secured.

Fig. 3561, lower cut, represents Dr. Emmett's double-curved scissors for paring edges in the operation of vesico-vaginal-fistula and cleft palate.

Par-is'ian Gold-col'ored Al'loy. A factitious gold. See OROIDE; also ALLOYS for jewelers, page 63.

Par-is'ian White-met'al. An alloy composed of copper, 69.8 parts; zinc, 5.5; nickel, 19.8; cadmium, 4.7. See ALLOY, page 63.

Pa-risth'mi-o-tome. (*Surgical.*) An instrument for scarifying the tonsils.

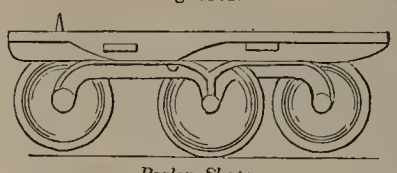
Park. A place of encampment of an artillery train.

Par'lia-ment-heel. (*Nautical.*) The position of a ship when careened.

Par-line. The mean or normal line of a barometer for a given station.

Par'lor-skate. A skate on rollers for use on a floor or carpet. (See SKATE.) In the one shown, the wheeling motion of the skater is facilitated by a middle driving-wheel which descends below a line drawn between the other two wheels.

Fig 3562.



Parlor-Skate.

Pa'ros-mar'ble. A semi-transparent white marble tinged with yellow.

Par'point-work. (*Masonry.*) Squared stones laid in *stretcher*-course and with *header*-courses at intervals of, say, 3 feet.

Par'quet-ry. An ornamental mosaic woodwork in the different colors of woods, or their different grains are so ordered as to form patterns. See also MARQUETRY; MOSAIC; BUHL; REISNER-WORK.

Par'ral. (*Nautical.*) The hoop or collar of greased rope by which a yard is shackled to the mast, at the slings, the *parral* slipping on the mast as the yard is raised or lowered.

Iron parrals are now in common use.

The parral is connected to sling-cleats on the yard, and has strung upon it *parral-trucks*, that is, small wooden globes to prevent friction or binding against the mast, in hoisting or lowering.

Par'ral-rope. (*Nautical.*) A single rope, well served, and formed into a collar around a mast for slinging an upper yard.

Par'rott-gun. (*Ordnance.*) A kind of rifled cannon invented by Captain R. G. Parrott of the Cold Spring Foundry, West Point, N. Y., and much employed in the United States service during the late civil war. The body of the gun is of cast-iron, and is reïnforced at the breech by shrinking on a ring of wrought-iron.

The calibers are, 10-pounder, 2.9 inches bore; 20-pounder, 3.67 inches bore; 30-pounder, 4.2 inches bore; 100-pounder, 6.4 inches bore; 200-pounder, 8 inches bore: corresponding respectively to 3, 6, 9, 32, and 64 pounder smooth bores. The number of grooves increased with the caliber of the gun, the 10-pounder having three.

Part. (*Founding.*) A certain portion of a mold or flask; as the *top part* or *drag*, the *bottom part* or *cope*, the *middle part* contained in the middle portion of a *three-part* flask, etc. (See FLASK.) The *false part* is a flask rammed up, generally a top part turned over, stricken off, and a cavity scooped in it to receive temporarily the bulge of a pattern while sand is being rammed upon the upper surface. The whole is then turned over, the *false part* destroyed, and the *parting* made.

Part'ing. 1. (*Metallurgy.*) Separating silver from gold by an acid.

2. (*Paper.*) Separating the moist sheets.

3. (*Nautical.*) Breaking cable, leaving the anchor in the ground.

4. (*Founding.*) The meeting surfaces of the sand rammed up in the *cope* and in the *drag.*

A powder is applied to the faces to enable them to separate readily. This parting may consist of dry sand free from clay or other tenacious matter, or of brick powder.

The *facing* is a material applied to the sand where the metal will come in contact with it. See FACING.

The *parting* of loam surface. See LOAM-MOLDING, page 1461.

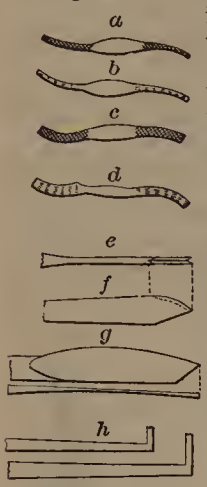
5. (*Comb-making.*) A mode of making combs to economize material, in which a pair of combs are made from a single slip a little over comb-width. A cutter has a vertical motion upon the blank, which has an intermittent feed beneath it, making a series of cuts, the teeth of each comb occupying the interdental spaces of the other. See COMB-MAKING.

Part'ing-line. (*Founding.*) The line upon a pattern as it lies imbedded in the sand, below which the *draw* of the pattern is upward, and above which it is downward. This line in the majority of cases is undulatory, and the surface of the sand-parting extends from it to the edges of the flask all round.

Part'ing-sand. (*Founding.*) Dry sand free from clayey compounds placed between the two members of a mold to facilitate their separation.

Part'ing-tool. 1. (*Marble-working.*) A rasp

Fig. 3563.



Parting-Tools.

of peculiar shape, coarse or fine in grain, and used by marble-workers (*a b c d*, Fig. 3563).

2. (*Turning.*) A cutting-tool used by wood and ivory turners for separating turned pieces from the block, turning out interior cylinders, etc.; *e f*, parting-tool for soft wood; *g*, for hard wood; *h*, inside parting-tool for removing rings from the interior of solid works, avoiding loss of material in shavings; it is also useful in some other under-cut works.

3. (*Carving.*) An angular gouge like a hollow graver, used for marking outlines, tendrils, stems, and markings of leaves, etc.

4. (*Joinery.*) A chisel with a bent edge.

Par-ti'tion. (*Carpentry.*) A division between rooms, etc.

The scantling in a partition is as follows: —

Sill, the bottom-piece.
Head, the upper plate.
Principal posts, the main uprights.
Quarters, the intermediate studding.
Braces, oblique ties.

Part'ner. (*Nautical.*) A framework or bushing in or around a hole in a deck to receive the heel of a mast, bitt, or pump, or to form a basis for the pawls of a capstan.

The framework consists of *fore-and-aft partners*, *cross-partners*, and *corner-chocks*.

Par'ty-gold. (*Metallurgy.*) Beaten or leaf silver with a coating of gold on one side.

Par'ty-wall. (*Building.*) A wall separating two adjoining tenements. Originally, it meant a wall built upon the lands of two adjoining proprietors which furnished support for the floors and roofs of the tenements on each side. Laws regulating this right of joint occupation are in force in Europe and America. It should run above the roof.

Par'vis. An area before the entrance of a church or around it. *Parvise.*

Pas-de-sou'ris. (*Fortification.*) A staircase from the ravelin to the ditch.

Pass. (*Rolling-mill.*) *a.* The shape produced by the grooves in the adjacent rolls of a rolling-mill. The *pass* is so formed as to give the required shape to the metal rolled therethrough. The most important and frequently occurring forms are rails, tires, angle-iron, deck or T and I beams, half-round forms, such as felly-iron, etc., and some of the principal varieties of spike and sash iron. See IRON, ANGLE.

b. A single passage of a plate or bar between the rolls.

Pas-sa-ree'. (*Nautical.*) A tackle to spread the clews of a fore-sail when sailing large or before the wind.

Pass-boat. A broad, flat-bottomed boat. A *flat* or *punt*.

Pass-box. A wooden box used for conveying cartridges from the magazine to the guns in forts and batteries. It is 7 inches in depth and width by 14 inches long, having a hinged cover and a handle at one end.

Passe-par-tout'. 1. (*Engraving.*) An engraved plate or block, forming a frame around an aperture into which any engraved plate or block may be inserted.

This is common in wood-engraving, where an ornamental border may be made to do duty with changing central advertisements or labels.

It was also adopted a number of years since with the notes of the State Bank of Ohio, when such things were, the inserted blocks representing the names of the several branches.

Also understood to be adopted in the national bank-notes.

2. A frame or mat to go around a picture. Frequently a pasteboard border for a picture beneath the glass and within the frame.

Pass'ing-place. (*Railway Engineering.*) A *siding*.

Pass'key. One that will open several locks. A *master-key*.

Paste. A soft adhesive composition.

1. A mixture of flour, water, starch, etc., variously compounded in different trades, such as *bookbinders*, etc. The paste is sometimes strengthened by starch, and preserved from mold by carbolic acid.

Size is a thin glue, but many pasty compositions are called size in the trades, as in calico-printing.

2. (*Calico-printing.*) A boiled composition of flour, starch, or gum with water, used as a vehicle for *mordant*, *color*, *resist*, or *padding*, or *discharge*. Also called *thickening*.

Sieburger's adhesive paste: Four parts, by weight, of glue are soaked for several hours in 15 parts of water, and then slowly warmed until a perfectly clear solution is formed. This solution is then diluted with 65 parts boiling water and thoroughly stirred. In the mean time, 30 parts of starch are stirred into 200 parts of cold water, so as to form a thin milky liquid, free from lumps. Into this is poured the solution of glue, stirring continually and heating. When cold, ten drops of carbolic acid are added. It is said to possess extraordinary adhesive power, joining leather, paper, pasteboard, etc. By keeping it in closed vessels, so that the water cannot evaporate, it may be preserved for years.

2. For attaching labels to glass or porcelain, gum tragacanth is generally employed. A small quantity of corrosive sublimate will preserve it, though this is seldom necessary. A solution of shellac in borax is also useful for this purpose. Dextrine, or British gum, is generally used for rendering labels adhesive, but does not adhere firmly to glass.

3. For leather-workers alum or rosin are added to the above.

4. *Chinese* paste is a cement of bullock's blood, quicklime, and water, for stone, earthenware, or wood.

5. *Furniture* paste is beeswax and turpentine.

6. *Polishing* paste, for metals, is made of materials of varying grit and vehicle, according to the need, — rotten-stone, emery, tripoli, bath-brick, soft-soap, olive-oil, lard, turpentine, etc.

7. *Shaving* paste is a perfumed soap.

8. Dough for pastry.

9. Certain confections, such as jujube.

10. (*Pottery.*) An earthy mixture for making ceramic wares.

11. (*Glass.*) A highly refractive vitreous composition of pounded rock-crystal melted with alkaline salts and colored with metallic oxides. Used for making factitious gems.

The kind known as *Strass*, from its inventor, is a highly refractive and pellucid glass. It contains a large quantity of oxide of lead, and frequently of borate of lead.

The art was known to the ancients, some specimens having been found in the Egyptian tombs. This wonderful nation also were possessed of the art of engraving gems. Among the Jews who made their exodus from Egypt was Bezaleel, of the tribe of Judah, who was able to cut, engrave, and set precious stones, to make the stones of the breastplate like "the engravings of a signet," each one with the name of one of the twelve tribes.

The art of making paste for gems was lost for many centuries, but was revived near the end of the fifteenth century by a Milanese.

12. Gypsum in water for plasterers.

Paste'board. A thick paper board, made by pasting together a number of sheets of paper. This is afterward pressed to remove the water of the paste, dried and calendered. See also CARDBOARD.

In Hale's machine for lining straw-board or thick paper with a thinner material, the thin lining-paper is wound on a roll *D*, and is caused to pass over a

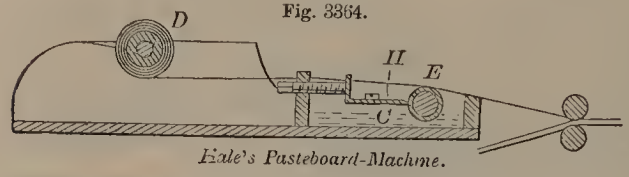


Fig. 3564.

Hale's Pasteboard-Machine.

pasting-roller *E* in the trough *C*, provided with an adjustable knife or scraper *H*. The thick board is fed up from below and united to the lining by a pair of rolls, between which the two conjomtly pass.

Paste'board-cut'ter. The machine (Fig. 3565) is for grooving and cutting pastcboard strips employed for making boxes. The board passes successively between the rollers *D F*, *C E*. The rollers *F* are provided with grooving disks *q*, which are opposed to the surface of the plain roller *D*, and may bc adjusted to crease the board at any desired distance from the edges severed by the circular cutters *n n* ; the roller *E* may be raised or lowered by screws *d d*, to cause more or less overlapping of the cutters *m n*.

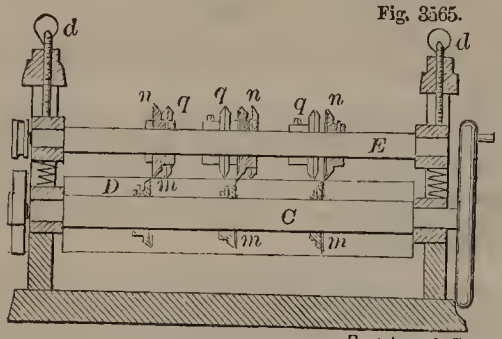


Fig. 3565.

Pasteboard-Cutter.

Pas'tel. 1. A solid colored pencil made of fine pipe-clay, gum-water, and the required pigment. The executed work is called a drawing in chalk colors. It requires the protection of glass.

2. (*Dycing.*) Woad. It gives its name to the vat in which pastel and indigo are used, the *pastel-vat.*

Paste-mak'er. A stirring-machine for mixing the components of paste. The vertical shaft is tubular at the lower end, and receives steam through its step-block, which is screw-threaded for coupling to the steam-pipe.

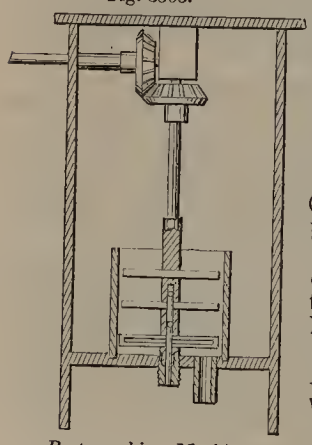


Fig. 3566.

Paste-making Machine.

Paste-points. (*Printing.*) Register-points on a tympan.

Paste-pot. (*Book-binding.*) A vessel containing paste, which is laid on with a brush.

Pas'tern. (*Menage.*) A shackle for horses while pasturing.

Pas-tille'. An aromatic paste for burning as a fumigator or disinfectant. It is composed of gum benzoin, sandal-wood, spices, charcoal-powder, etc.

Pat'a-mom'e-ter. An instrument for measuring the force of currents.

Patch. 1. A greased piece of cloth wrapped around a rifle bullet.

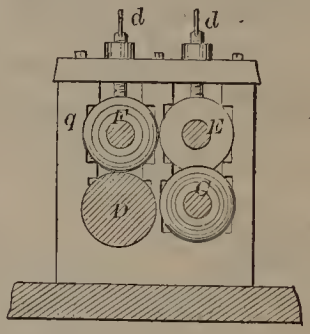
2. A reïnforce or strengthening piece on a fabric at a point of wear, or around a hole or eyelet.

3. An additional or substitute piece in the covering or sheathing of a structure.

4. A binding or clamp on an emergency for a ruptured hose.

5. A block on the muzzle of a gun to do away with the effect of dispart ; making the line of bore and line of sight parallel.

Pa-tel'la-ap'pa-ra'tus. (*Surgical.*) An apparatus for treating fractures of the kneepan. It consists of two curved plates of sheet-iron connected by two side rods and a back rod *a*, having attached a double reversed screw with a key *b*, by turning which the two projections *c d* are caused to approach or recede from each other. Two buckling straps are attached to each plate ; these are applied to the lower part of the thigh and calf of the leg. The fractured parts are coapted, and strips of adhesive plaster *e f* applied above and below the kneepan ; these are tightened by turning the key *b*, keeping the parts of the kneepan together.



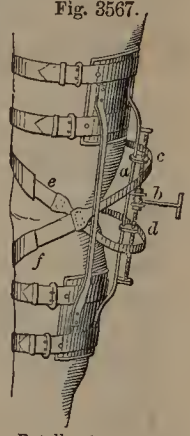


Fig. 3567.

Patella Apparatus.

Pat'en. The plate which holds the wafer or consecrated bread of the communion service. It is sometimes made to fit the *chalice* or cup.

Pat'ent Leath'er. A varnished or lacquered leather used for boots and shoes and in carriage and harness work. It embraces a number of varieties and qualities. Black is the usual color, but it is also made of red, green, blue, and other tints.

The leather is specially prepared for the purpose, and is usually hemlock tanned ; it is highly limed and treated with weak sour liquor, undergoing but a light *stuffing*. The hides are then split, some of the thicker ones being passed through the machine as many as five or six times ; the skin and flesh side splits are usually sold to trunk-makers, the interior only being treated with the *sweetmeat*, as the lacquer is technically termed ; this is principally composed of linseed-oil, with the addition of proper coloring matters. The skins, previously well dried and softened by beating and *boarding*, are stretched on frames, and the *sweetmeat* is applied in several coats ; after each application the frames are slid into an oven heated by steam-pipes, where they remain until the varnish has set ; any roughness that appears during any stage of the process is removed by polishing with pumice, and all traces of dust removed with a wet brush followed by a dry one. The entire operation requires from one to three weeks.

The variety known as *enameled* leather is finished by passing through a graining-machine having a heavy brass roller with a slightly corrugated face, and boarding in a peculiar manner by hand. See LEATHER.

Pat'e-ra. (*Architecture.*) An ornament on a frieze representing a round dish in bas-relief.

Pat'e-re'ro. (*Ordnance.*) A mortar for firing salutes.

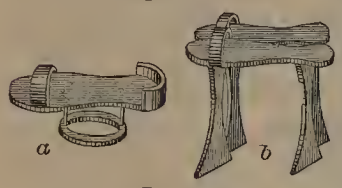
Pa'ter-nos'ter - pump. A *chain*-pump. So named from a fancied resemblance of the buttons on the chain to the beads of the rosary. The latter is an old invention of Central Asia, used by the Boodhists. See CHAIN-PUMP.

Pa'ter-nos'ter-wheel. A water-raising device having a number of buckets on a chain. Named from its resemblance to the rosary. See NORIA; CHAIN-WHEEL.

Pa'tio-pro'cess. The patio-process of amalgamation is practiced in Peru and Mexico. A *patio*, or *amalgamation floor*, is a large paved area, walled around to contain the *tortas*, or flat, circular heaps of ground ore, salt, magistral, etc., which are tramped by horses, treated by mercury, etc., as described under AMALGAMATOR, page 75 (which see). The process was invented by Medina in 1557, and was introduced into Nevada with but indifferent success.

Pat'ten. 1. A clog or sole of wood mounted on a frame to raise the feet of a person above a wet or muddy pavement. The support is usually an iron ring. They are much used in some countries where *sabots* are not in vogue. The Dutch wade round in *wooden shoes* in their dairies and scullcries. The English and French of the wealthier class use *clogs;* the more humble class in England use *pattens* (*a*); in France, *sabots*. The Oriental ladies patter round in their baths and paved courts, wearing *kŭbkobs* (*b*), to protect the soles of their delicate feet.

Fig. 3568.



Pattens.

2. (*Masonry.*) *a*. The sole for the foundation of a wall.

b. The base ring of a column.

Pat'tern. 1. A piece of card-board, sheet-metal, or thin plank corresponding in outline to an object that is to be fabricated, and serving as a guide for determining its exact shape and dimensions; such are employed by workers in leather, textile fabrics, and other thin materials for cutting out work, and also by wood-workers for laying off the outlines of objects of irregular form which are afterward shaped by the axe or saw. (See TEMPLATE.) Pattern-pieces or *gages* are largely used in making special machinery, such as rifles, sewing-machines, American watches, and numerous machines in which all the parts are made separately by gages and then *assembled*.

The system is known as *making by gages* and *assembling*. See GAGE; ASSEMBLING.

2. (*Fabric.*) A design of figures, woven in cloth or printed thereon.

3. (*Founding.*) The counterpart of a casting in wood or metal from which the mold in the sand is made. When dry-sand or loam-cores are used to form the cavities in a casting, projections of suitable size and shape are affixed to the pattern to secure such cores in place. See PRINT.

Patterns are often made in two parts, sometimes in several parts, held together by steady-pins or dowels.

Straight-grained pine or mahogany is preferred for patterns of this kind; screws rather than nails are employed for joining the pieces. Foundry patterns are made somewhat tapering in those parts which have to enter deeply into the molding sand or loam, in order to facilitate their removal; this taper may amount to $\frac{1}{16}$ or $\frac{1}{8}$ of an inch to the foot, and in some cases even more.

Ordinary iron shrinks about $\frac{1}{8}$ inch to the foot in cooling; brass, $\frac{3}{16}$ inch; and this must be allowed for in the pattern. For this purpose a contraction rule is employed, giving measurements about one per cent in excess of the true length; this avoids the trouble of calculating the extra dimensions to be given the pattern in each particular case.

Wooden patterns should be well oiled and varnished. This preserves them and assists their free delivery from the mold, which is farther insured by rubbing them with black-lead. In their construction, sharp interior angles should be avoided as tending to cause a breaking down of the mold at that point and weakening the casting. Patterns, especially for small castings, are sometimes made of metal. These have the advantage of being more durable, but if of iron require to be taken good care of to prevent rusting. See list under FOUNDING; MOLDING.

For machine for pattern-making, see numbers of *American Artisan* for May and June, 1874.

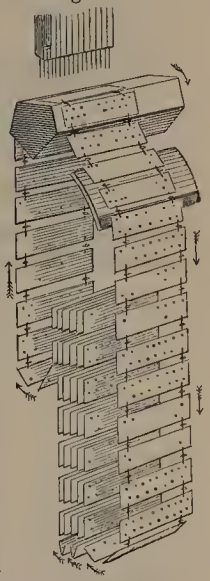
Pat'tern-box. (*Weaving.*) *a*. A box in a loom holding a number of shuttles, either of which may be projected along the shed, according to the pattern. The automatic means for operating the shuttles in due sequence is a PATTERN-CYLINDER or PATTERN-CHAIN (which see).

b. The box perforated for the harness-cards in the Jacquard figure-loom. See PATTERN-CARD.

Pat'tern-card. (*Weaving.*) One of the perforated cards in a Jacquard loom through which the needles pass; the perforations are according to the pattern.

Fig. 3569 shows the pattern-cards and pattern-box detached from the loom. The box is perforated with as many holes as there are warp-threads, and rods connected with each thread are suspended over it. The pattern-cards are perforated to correspond with the figure to be woven. As the box revolves, carrying the cards successively over its faces, the rods drop down whenever the holes in the cards and box coincide, each rod lifting its own warp-thread. The cards are hung together in an endless belt, as shown in the figure. See also pages 1356, 1357.

Fig. 3569.



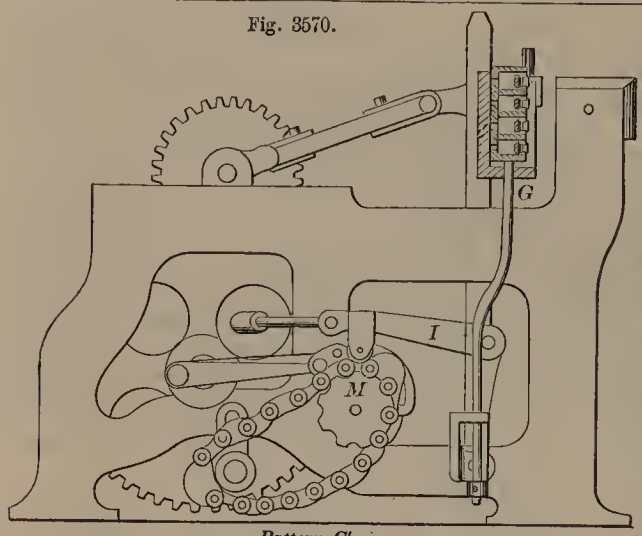
Pattern-Card of Jacquard Loom.

Pattern-chain. (*Weaving.*) A device for automatically bringing to the picker, according to the sequence required by the pattern, the shuttles in the shuttle-boxes at the ends of the race.

In Fig. 3570, the pattern-chain is shown passing over the wheel *M*. It has links of varying hight, which, as they pass beneath the roller on lever *I*, raise it to a greater or lesser hight, and with it the rod *G* and the shuttle-box at its summit, and so bring the required shuttle in position to be struck by the picker.

In Fig. 3571 the pattern-chain is shown beneath the levers *P*, from whose ends depend rods which control the movements of the lever *E*. This lever is connected by a link to a standard *F*, upon which latter the shuttle-boxes *B* are mounted, and is operated by two cams *H* and *I*, in such a manner as to raise or lower the standard upon which the series of shuttle-boxes are placed, so that any one of the boxes may be brought to the race from any position at every pick. The cams are actuated by a pawl and

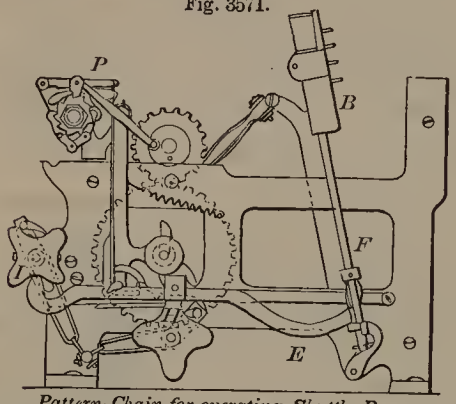
Fig. 3570.



Pattern-Chain.

ratchet connected by rods with levers *P* placed in contact with the revolving pattern-chain.

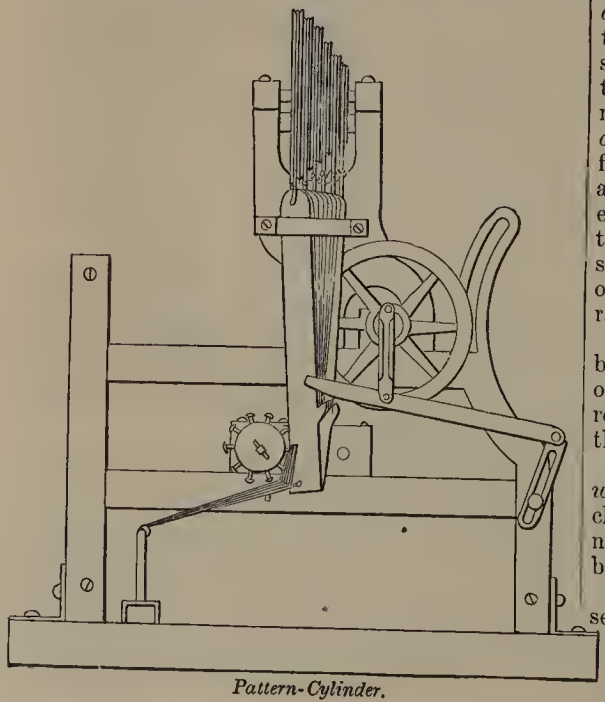
Fig. 3571.



Pattern-Chain for operating Shuttle-Box.

Pat'tern-cyl'in-der. (*Weaving.*) A means of operating the harness of a loom by means of a cylinder with projections which come in contact in due order of time with the respective levers which work the shed. In the example, the pattern-cylinder shaft is free at one end to admit of changing the cylinder readily for changing the pattern. The graduation in the sizes of the pulleys placed in series on the same shaft allows a true vertical pull upon each of the jacks, which are arranged side by side beneath.

Fig. 3572.

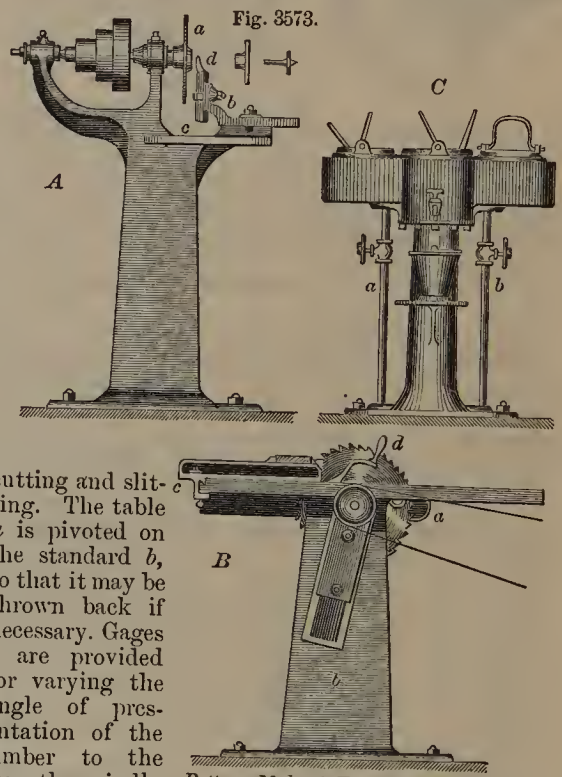


Pattern-Cylinder.

Pat'tern-mak'ers' Ap-pli'an-ces. These embrace various modifications of the tools and machines ordinarily used by the turner and joiner. Among others may be cited the *face-lathe* (*A*, Fig. 3573), for turning hubs, bosses, core-prints, etc. This is a compact machine, occupying a space of but two feet square; the cone-pulleys are of iron; the spindle of steel turns in brass bearings, and the face-plates *a*, of which two are provided, are capable of taking work up to 16 inches in diameter. The rest *b* is adjustable on the table *c* by a nut and screw, and the hight of the cutter *d* is also regulated by a screw.

B is a *blocking* and *cropping saw* adapted for cross cutting and slitting. The table *a* is pivoted on the standard *b*, so that it may be thrown back if necessary. Gages *c* are provided for varying the angle of presentation of the timber to the saw, the spindle of which may be raised or lowered by means of the wrench *d*.

Fig. 3573.



Pattern-Makers' Face-Lathe, Blocking-Saw, and Glue-Heater.

C is a *steam glue-heater*. The pots, three in number, have flanges resting on the smooth upper surface of the heater, which consists of a water-bath surrounded by a steam-chamber. *a* is the steam and *b* the waste-water pipe.

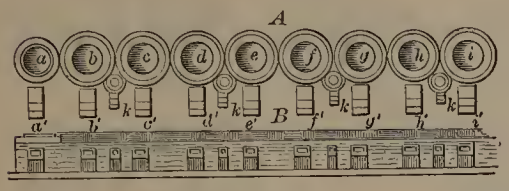
Pat'tern-wheel. 1. (*Horology.*) The *count-wheel* or *locking-plate* of the striking portion of a clock-movement. That which has notches of such number or such distance as will determine the number of blows in regular order.

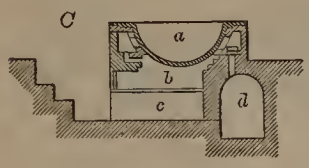
2. (*Weaving.*) A PATTERN-CYLINDER (which see).

Pat'tin-son's Pots. (*Metallurgy.*) An arrangement invented by Mr. H. L. Pattinson of Newcastle-on-Tyne, about 1829, for separating

silver from lead. Lead ores always contain a small proportion of silver. By the ordinary process of cupellation, it does not pay to treat lead containing

Fig. 3574.





Pattinson's Pots.

less than 20 ounces of silver to the ton for the purpose of extracting the silver, but by Pattinson's process that containing as little as 3 ounces per ton may be profitably worked.

This process is based on the fact that the melting-points of alloys of silver and lead are higher in proportion to the amount of silver contained, and that if lead containing silver be melted and constantly stirred while gradually cooling, when it arrives at a temperature near the melting-point of lead, crystals will begin to form, which sink to the bottom, leaving the still fluid portion much richer in silver than the whole mass originally was, while, on the contrary, the crystallized portion has become poorer.

The apparatus consists of a series of eight or ten cast-iron pots set in a row, with fireplaces beneath. At the commencement of the operation one of the central pots, as *f*, is charged with lead from the calcining-furnace, which, when melted, is skimmed with a perforated ladle and the fire withdrawn; cooling is accelerated by throwing water on the surface of the metal, which is kept constantly agitated by means of a stirrer or slice. Crystals soon appear and fall to the bottom, whence they are removed by means of a perforated ladle and transferred to the pot *e* at the left; this operation is carried on until about two thirds of the charge has been transferred to the pot *e*, at which time, supposing the original charge to have contained 20 oz. of silver per ton, that remaining in the pot *f* will contain about 40 oz., and that removed to *e* but about 10 oz. per ton. The rich lead in *f* is then ladled into *g*, a fresh charge of calcined lead introduced into *f*, and the operation repeated, the richer metal being constantly transferred from one pot to another toward the right, while the poorer is passed from pot to pot in the reverse direction. In this way the crystals obtained from the pots to the left are gradually deprived of their silver, while those on the right are being continually enriched, the metal in the pot on the extreme right frequently being concentrated until it contains 500 oz. of silver per ton, while that in the pot on the extreme left should not contain more than 12 dwts. per ton.

A is the plan; *B*, the elevation; and *C*, a transverse section of the apparatus; *a* is the *market-pot*, from which the desilverized lead is ladled; *b c d e f g h i*, the *working-pots; a' b' c' d' e' f' g' h' i'*, their respective fireplaces; and *k k k k*, the *temper-pots*, in which the ladles are heated when they become cool.

In the section, *a* is a pot; *b*, grate; *c*, ash-pit; *d*, main flue.

The ladles, if operated by hand, are about 16 inches in diameter and 5 inches in depth; when cranes are employed much larger ones may be used.

Paunch. 1. (*Nautical.*) A thickly thrummed mat of sennit wrapped around a spar or rope to keep it from chafing.

2. The rim of a bell. The part against which the clapper strikes.

Paved Way. A tramway whose tracks are of stone.

Pave'ment. The hard covering of the surface of a road or foot-way.

According to Pliny (A. D. 79), "pavements are an invention of the Greeks." As usual, he forgets Egypt and is oblivious of India and China. Sosus of Pergamus (founded 283 B. C.) made ornamental mosaic pavements representing natural objects. The first Roman pavement in blocks of diamond (rhombal) form was laid in the temple of Jupiter Capitolinus during the third Punic war.

The Greeks invented (says the same author) terrace-roof pavements, and he gives the following directions for their construction: —

"Begin with two layers of boards crossing each other and nailed together at their extremities, to prevent warping. Next place a layer of pounded pottery and lime; upon this place a layer of broken pottery with a large proportion of lime, one foot thick and rammed. Another layer of pottery three parts, lime one part, is laid down, six fingers in depth. Square stones, two fingers thick, are laid on this on a slope of 1½ inches to 10 feet. Then polish the surface."

Pliny gives a formula for pavement which has the ordinary appearance of the ground when in the rough, but may be polished to resemble marble: —

Upon well-rammed ground place a layer of broken crockery, above this a layer of charcoal well trodden down with a mixture of sand, lime, and ashes, making the upper layer a depth of six inches.

Strabo informs us that the city of Babylon was paved at a very early date. The date assigned (2000 B. C.) is perhaps fabulous, though it was quite within the capacity of the builders of the city walls, palaces, and the bridge across the Euphrates, to pave the city in good style.

Isodorus says that the Carthaginians had the first paved streets, and that their example was soon copied by the Romans. Appius Claudius, the censor, constructed (312 B. C.) the road named after him, the Appian Way, which was, on account of its excellence, called the *queen of roads*. This was about ten years after the death of Alexander the Great. The time, however, when the streets of Rome were first paved cannot be determined with certainty. We are informed by Livy, that in the year of the city 584 (about 170 B. C.), the censors caused the streets to be paved from the ox-market to the temple of Venus.

The extravagant Heliogabalus caused the streets around the palace or on the Palatine Mount to be paved with foreign marble. Streets paved with lava, having deep ruts worn by the wheels of carriages, and raised banks on each side for foot-passengers, are found at Pompeii and Herculaneum.

Roman country roads were 8 feet wide on the straight lines, 15 feet at angles. Cattle might be driven on each side, if not fenced in.

Abderahman, the khalif of Cordova, Spain, caused the streets to be solidly paved, A. H. 236 (A. D. 950), and a man might walk after sunset ten miles in a straight line by the light of the public lamps. 700 years after this, London and Paris were unpaved and had no public lamps.

The capital of France was not paved in the twelfth century, for Rigord, the physician and historian of Philip II., relates that the king, standing one day at a window of his palace near the Seine, and observing that the carriages which passed threw up the dirt in such a manner that it produced a most offensive stench, his majesty resolved to remedy this intolerable nuisance by causing the streets to be paved, which was accordingly done. The orders for this purpose were issued by the government in the year 1184, and upon that occasion, it is said, the name of the city, which was then called Lutetia, on account of its dirtiness, was changed to that of Paris. In 1641, the streets in many *quartiers* of Paris were not yet paved.

Dijon, at that time reckoned one of the most beautiful cities of France, had paved streets as early as 1391; and it is remarked by historians that after this period dangerous diseases, such as dysentery, spotted fever, and others, became less frequent in that city.

The streets of London were not paved at the end of the eleventh century. It is related that in the

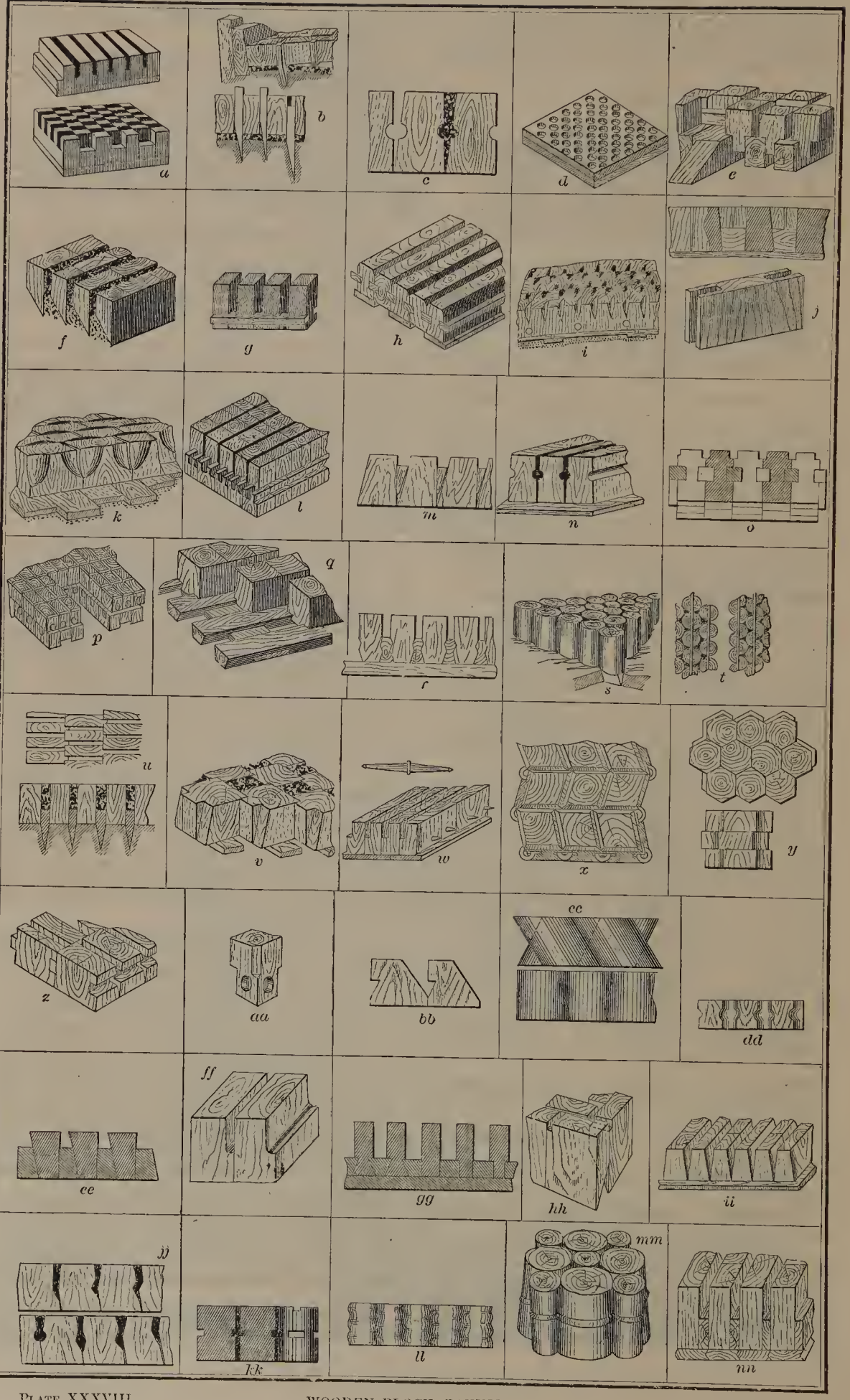


PLATE XXXVIII. WOODEN-BLOCK PAVING.

See page 1639.

year 1190 the church of St. Mary le Bow, in Cheapside, was unroofed by a violent wind, and that four pillars, 26 feet in length, sunk so deep into the ground that scarcely four feet of them appeared above the surface of the soft earth forming the bed of the street.

The pavements of this great city appear to have been gradually extended as trade and opulence increased, though the period of their first introduction is unknown. Several of the principal streets, among which was Holborn, were paved for the first time in 1417. Smithfield cattle-market was first paved in 1614.

Blocks of wood set endways are a common pavement in Russia and Germany. Blocks of wood or stone inclosed in iron frames were in use in England thirty or forty years ago.

In 1812, Loudon suggested laying cubic blocks on a foundation of flag-stones, or cast-iron plates on a bed of mortar.

George Knight (London, P. 3720), London, 1829, suggested laying the granite blocks on a macadamized foundation. This, with grouting for rendering the pavement water-tight, and with under-drainage, is pronounced by Loudon one of the best modes of paving.

Lieutenant Brown (England, 1830) suggested a gravel foundation, dressed blocks of granite laid in mortar and grouted.

One form of the London pavement has granite blocks 6 × 4 inches on a bed of gravel, filled in with grouting, and solidified by a hot liquid cement of gas asphalt.

A part of Broadway, between Chambers and Warren Streets, was laid in 1835 with hexagonal wooden blocks. Various foundations were tried: cobble-stones, flagging, and macadam. The upper surface of the pavement was coated with a layer of tar and gravel.

An English patent, 1838, describes tapering wooden blocks boiled in tar and doweled together.

A subsequent English inventor aggregated his blocks in clusters in iron frames, which were fitted together.

In Parkin's English patent, 1840, the blocks are placed at angles of from 40° to 70°. The surfaces of the blocks were channeled, and they were cemented together in the pavement, their interstices being filled with pitch. Sand or ashes and tar was used in the foundation.

Previous to 1841, a system of foundation-boards was exhibited in New York, and in 1841 the blocks were interlocked by notched shoulders.

A pavement has been suggested, composed of iron perforated in such a manner as to afford a footing for horses, and to permit the sweepings to fall through upon a sub-pavement made of cement and depressed at the center, so that the offal can be swept therefrom to the sewers by simply flushing with water. It is said to have been put in operation in St. Louis. Cost, $3.66 per square yard.

Knight's patent consisted of blocks made of iron run into molds packed with hot granite fragments. This saved metal, which nevertheless could be run into form, and the granite gave the requisite roughness to the wearing surface.

Among the pavements now in common use may be enumerated: —

Ashlar, consisting of squared blocks of stone, generally granite, usually 12 inches deep, 8 to 12 long, and 5 to 7 wide.

Asphalt, a foundation of coarse broken stone and a top dressing of finer stone and perhaps sand or gravel, all cemented together by an asphalt.

Belgian, similar to ashlar, but of smaller blocks.

Bowlder, irregular stones brought to a comparatively even surface by resting on an uneven foundation of sand or gravel.

Cobble, stones naturally rounded, and of nearly equal size, rammed down in a bed of sand.

Concrete, similar to asphalt, except that tar or pitch is used, sometimes in conjunction with natural asphalt.

Granite, blocks of granite, either ashlars or irregular broken stones from the quarry.

Slag, refuse from the furnace, sometimes concreted; at other times run into molds to form blocks.

Wooden, blocks sawed to an even length, set endwise to the wear of travel.

Macadamizing was named from the inventor, and introduced in 1824. It consists in substituting broken granite for gravel as a top dressing, and is much superior to the latter for country roads, but will not stand the heavy wear of city travel.

Haussmann laid 1,250,000 yards of macadam in the streets of the city of Paris, as a substitute for the stone blocks, the material of barricades in revolutions.

In the *Snow* pavement no natural asphaltum is used; the raw coal-tar is treated with sulphuric acid, and mixed with lime and cement, and is said to produce a compound similar to the Neufchatel rock.

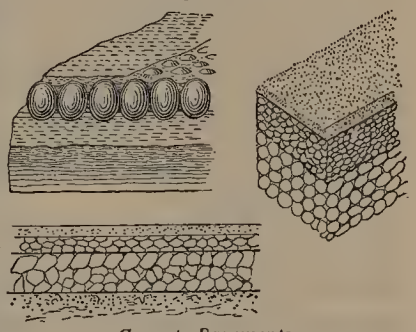
The *Scharff* pavement uses bitumen and the heavy tar-oils for the base, bitumen and a small quantity of natural asphaltum for the top courses.

The *Vulcanite* pavement makes Trinidad asphaltum the basis of the composition, treating the same with sulphuric acid or sulphur and cement.

The *Neufchatel rock* pavement has a base of a concrete of broken stone and bituminous or asphaltic compounds. This base being perfectly dry, a coating of that peculiar formation known as the Neufchatel rock, and which is a natural and intimately combined mixture of asphaltum with calcareous matter, is spread in a powdered state, well heated, and compressed by beating down with heated cast-iron pestles into a hard, smooth mass. The compression is completed by heavy rollers.

Fig. 3575 shows three varieties of concrete pavement.

Fig. 3575.



Concrete Pavements.

Solid concrete and asphaltum pavements are hard and elastic; are not affected by the alternations of heat and frost; they have no joints to encourage the growth of weeds and accumulation of filth; are therefore free from dust and mud. They dry in a few moments after a rain, are smooth, and yet not so even as to become slippery, especially when occasionally sprinkled They afford an easy, noiseless, and pleasant drive; decrease the cost of keeping the street in repair, by confining the latter to the top dressing; and effect a large annual saving in horse-flesh and wear and tear of vehicles.

The *Nicolson* pavement, which was among the first wooden pavements used extensively in this country, consists of a foundation of boards laid flat upon the ground, and a superstructure of blocks sawed to an even length of 4 to 6 inches, and 2½ or 3 inches thick. The blocks are laid across the street, and secured by a thin strip of board nailed at the bottom, reaching not quite to the surface. The space thus left above the strip is filled with fine gravel, to afford a holding surface to horses' feet. The whole then receives a top dressing of tar. Another form has alternate short blocks, the spaces filled with gravel.

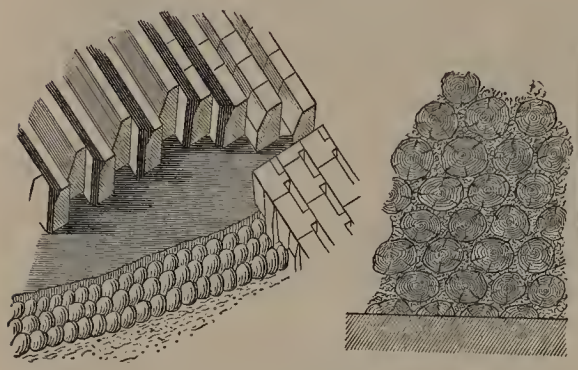
Numerous varieties of wooden pavement have been patented in the United States, and some of them are very extensively used. Plate XXXVIII. shows forty varieties of patented pavement. The difference between them lies in the form of blocks, method of laying, foundation, and chemical treatment or otherwise of the wood.

The greatest enemy to wooden pavements has been dry-rot from below. The surface of a well-laid pavement soon becomes water-proof from dust beaten into the pores of the wood, and if sufficient incline is given to the surface rain will flow off as from a roof. Dampness from below is drawn into the blocks by capillary attraction, and the lower part of the blocks crumbles into dust while the shell on top remains perfect. To prevent this decay, compound pavements, which exclude the absorption of the moisture of the soil by means of a layer of asphalt, would seem to offer more chances for duration than

any other system, especially if the wood has been chemically treated.

Of these compound systems used, two forms are shown in Fig. 3576, one employing square blocks

Fig. 3576.



Compound Pavements.

and the other round blocks on a concrete foundation. See WOOD, PRESERVATION OF.

Pa-vil'ion. (*Music.*) Fr. *Pavillon*, from its tent-shape. The flaring mouth of a horn, trumpet, or wind-instrument of that class. The insertion of the hand into the *pavilion* of the French horn regulates the inflection of the sounds.

2. (*Architecture.*) *a.* An isolated building of ornamental character.

b. A turret rising from the general hight of a building.

c. A projecting apartment of a building.

d. A tent-shaped roof.

3. A tent; a marquee.

4. (*Gems.*) The part of a diamond or other gem below the *girdle* and between it and the *collet.*

Pa-vil'ion-chi-nois'. (*Music.*) An instrument having a number of small bells in a frame, which is agitated by striking the staff on the ground. It is especially used in marching music.

Bells, *high* and *low*, are used in military music, and occasionally for dramatic effects in operas.

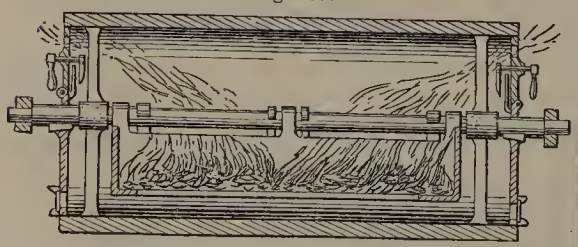
The *glockenspeil* is an instrument in which bells are rung by keys; in one case bars of steel are substituted for bells.

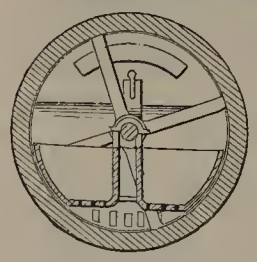
Gongs and *triangles* are but forms of bells.

Pav'ing-bee'tle. A rammer used by paviors.

Pav'ing-ma-chine'. A traveling rammer, like

Fig. 3577.





Paving-Roller.

a small pile-driver, traveling over the surface of the pavement and ramming down the blocks, was invented about 1830 by Colonel Macirone, London.

A steam paving-machine in use in Paris consists of a small steam-engine on wheels, drawn by one horse, to the rear of which is attached the pavior or vertical rammer, which is forced upon the ground with great force by a blow from the piston. It slides on a bar some six feet long, and can thus be directed by the driver to any stone which requires forcing home.

Lignier's machine (French) consists of a small Lenoir steam-engine, to the fly-wheel of which is attached a rammer of steel, smaller and heavier than the wooden one in general use. The operator simply guides the strokes of the machine.

Pav'ing-roll'er. A heated roller for compacting asphalt pavement. In the example, a cresset or fire-basket is suspended within the roller in such a way as to preserve its proper position during the rotation of the roller.

Pav'ing-tile. A flat brick for paving floors. Such are often of an ornamental character, enameled, encaustic, etc. See TILE.

Tiles employed in offices, kitchens, etc., are usually from 9 to 12 inches square.

Pa'vi-or. 1. A paving-brick.

2. A rammer for driving paving-stones.

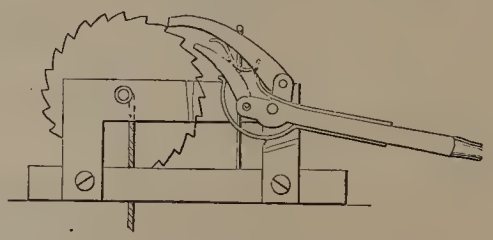
Pawl. A pivoted bar adapted to fall into the notches or teeth of a wheel as it rotates in one direction, and to restrain it from back motion. Used in windlasses, capstans, and similar machinery. The pawl acts by gravitation or by a spring.

The same device is called a *click* when acting in connection with a ratchet-wheel, as in the winding part of a watch.

It is sometimes called a *detent.* This is its office, but the thing has already names enough.

Figs. 3578, 3579, 3580, show three applications

Fig. 3578.



Pawl in Hoisting-Apparatus.

of the pawl, and many others may be found incidentally shown in connection with devices, such as *click*, *ratchet*, etc.

Fig. 3578 is a hoisting lever having a pair of pawls acting upon a ratchet on the shaft of a windlass.

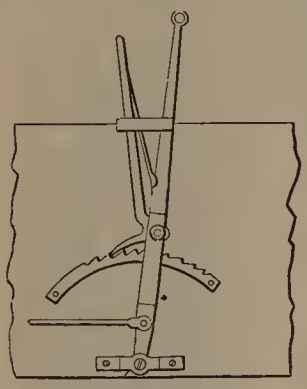
Fig. 3579.

Pawl in Harvester-Wheel.

Fig. 3579 shows the pawl and ratchet gear of the driving apparatus of a harvester. As the machine moves in a curve, one of the propelling wheels will revolve faster than the other, and the link which connects the pawl with the friction-band is silently disengaged from the teeth of the case on the outer curve. When the machine turns a curve in the opposite direction, the pawl is made to engage with the teeth.

Fig. 3580 shows the application of a click and ratchet holding-device for a wagon-lock. A handle, which is secured to the pawl, extends upward and slides in a guard attached to the brake-lever. It is used to release the pawl from the ratchet.

Fig. 3580.



Pawl on Wagon-Lock.

The mode of rotating the barrel of the Colt

Fig. 3581.

Feed-Motion of Colt's Pistol.

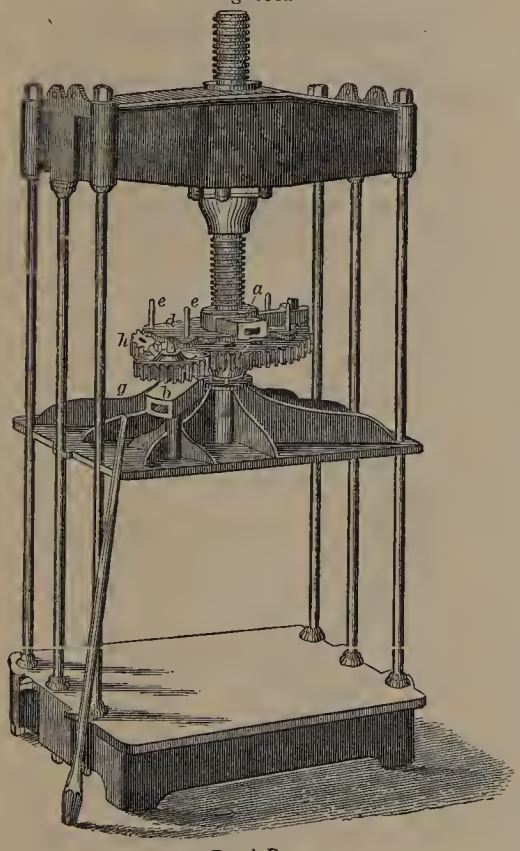
pistol is by means of a pawl pivoted to the lower part of the hammer, and acting upon a crown ratchet on the rear of the barrel. As the hammer is brought to the cock, the pawl *a* rises, being kept to its work by a spring *c*, which forces it into the interdental spaces of the ratchet. As the hammer falls, the pawl slips and takes hold of the next ratchet-tooth.

Pawl-bitt. (*Nautical.*) A timber opposite the middle of the windlass supporting the pawls which engage the ratchet of the barrel.

Pawl-post. (*Nautical.*) A timber to withstand the thrust of the pawls of a windlass. A *pawl-bitt*.

Pawl-press. A standing press used by bookbinders and printers for pressing sheets, etc. It is next in power to the hydraulic press, and is operated by a lever inserted into the sockets *a b*, and another

Fig. 3582.



Pawl-Press.

not shown. The plate *d* has beveled pins *e*, which drop into the beveled slots *f* when the lever is turned, so as to produce a downward motion of the screw, and rise therefrom when it is turned in the opposite direction; pawls are also caused to engage the smaller wheels *g h*, each of which in turn serves as the driver, by inserting the lever into an appropriate socket, the smallest wheel when thus employed affording the greatest power.

Pawl-rim. (*Nautical.*) A notched cast-iron rim encircling the barrel of the windlass, and serving for the pawls to catch in.

Pay. (*Nautical.*) *a*. To cover or fill with a water-proof composition or substance, as the bottom of a vessel, a seam, a mast, yard, or rope. The materials used are tar, pitch, tallow, resin, etc., or combinations of them.

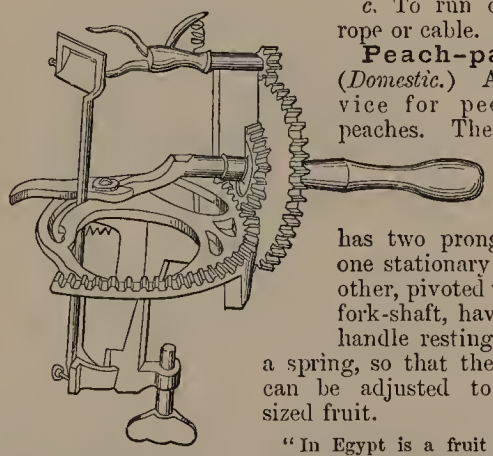
Weather-decks are *payed* with marine glue; a solution of caoutchouc and shellac with naphtha.

Decks are payed with a ladle; seams, with a ladle or mop; other surfaces with a brush.

b. To fall off from the wind.

c. To run out a rope or cable.

Fig. 3583.



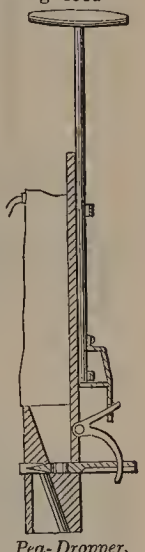
Peach-Parer.

Peach-par'er. (*Domestic.*) A device for peeling peaches. The fork has two prongs, — one stationary; the other, pivoted to the fork-shaft, having a handle resting over a spring, so that the fork can be adjusted to any sized fruit.

"In Egypt is a fruit called *persica*, of wonderful sweetness. This was brought out of Ethiopia by the Persians when Cambyses conquered these places."— DIODORUS SICULUS (60 B. C.).

Rather say, brought by the Persians from home. They brought little with them from Ethiopia except disgrace. The peach (*persica*) is Persian. It was introduced from the East into Europe by the Arabs. Its congeners, the nectarine and apricot, are also natives of Asia.

Fig 3584.



Pea-Dropper.

Peach-ston'er. An implement for thrusting the stone out of a peach while holding the fruit; or, with free peaches, dividing the fruit, so that the pit may drop out. In one case, the peaches are fed between wheels with corresponding concave faces and drawn against knives, which open the peach and deliver the halves and the stones at different places.

Pea-drop'per. (*Husbandry.*) An implement for planting pease in hills. It resembles the corn-planter in material respects.

With the down stroke the elbow-lever is vibrated, pushing the slide and its contents over the dropping-hole, whence it falls into the ground. As the handle and implement are raised, the slide returns and is refilled.

Peak. 1. (*Nautical.*) *a*. The upper, after corner of a *trysail*, *spanker*, or *sprit*-sail.

b. The upper end of a *gaff*. The national ensign is flown at the *peak*.

c. To *top* a gaff or yard more obliquely.

d. To raise the oars upright amidships.

e. The pointed *bill* beyond an anchor's *palm*.

2. The leathern front of a cap.

Peak-arch. (*Architecture.*) A pointed, or *Gothic* arch.

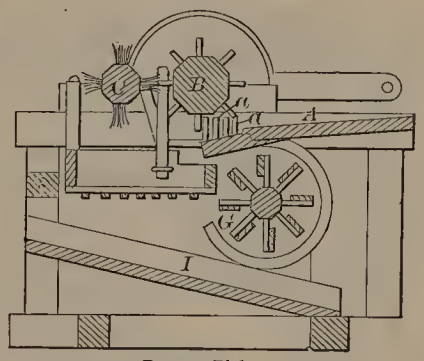
Peak-hal'yards. (*Nautical.*) The purchase by which the peak of a gaff is raised. The throat which rests against the mast has its *throat-halyards*.

Pea'nut-dig'ger. A kind of plow with trailing branches, which raises from the soil the vines with the nuts attached, and leaves them strung upon the surface of the ground, to be afterward gathered and picked by hand or by machine.

Pea'nut-pick'er. A machine for separating peanuts or the pods of leguminous plants from their vines.

These are fed down the incline *A*, and, in passing between the spoked cylinder *B* and upright teeth *a a*, the pods are torn from the stalks and fall upon a sieve to which a vibratory motion is imparted by a lever and a cam on the cylinder *B*. A

Fig. 3585.

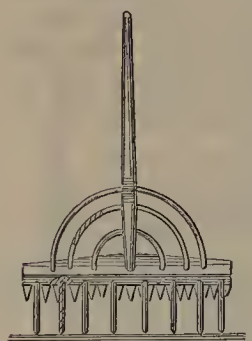


Peanut-Picker.

strong blast directed from the fan *G* above and below the sieve blows away the vines, while the pods fall through upon the incline *I* and are delivered into a proper receptacle. A rotary brush *C* clears the spaces between the spokes on the cylinder *B*

Pea-rake. A rake adapted for gathering the field pea.

Fig 3586.



Pea-Rake.

The toothed cutter on the rake-head cuts off the vines which the rake has gathered.

Pear-gage. A gage for measuring the exhaustion of an air-pump receiver. It consists of a tube open at bottom and held by a wire passing through the top of the receiver, so that after exhaustion it may be lowered into a cup of mercury, the degree of exhaustion being shown by the hight to which the mercury rises when the air is readmitted.

Pearl. (*Printing.*) A size of type between Diamond and Agate.

Diamond, 205 ems to a foot.
Pearl, 178 ems to a foot.
Agate.
Nonpareil, 143 ems to a foot.

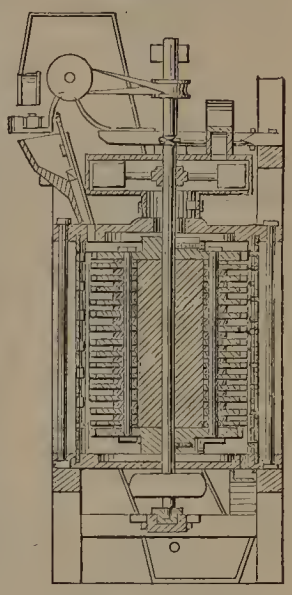
Pearl, Ar'ti-fi'cial. A hollow glass bead internally coated with a pearly film derived from the scales of certain fish.

Pearl-ash. A somewhat impure carbonate of potash obtained by leaching wood-ashes.

Pearl-bar'ley Ma-chine'. A machine for taking the hull from barley grains.

The grain is placed in one of the two hoppers, and passes through the annular space between the toothed cylinder and the case. The cylinder has horizontal toothed rings alternating with plain ones. The shell has holes with the burrs inside, and oblique slots which incline to the right and left, to operate when the cylinder is turned in either direction, according as the grain is furnished by one or the other hopper. An adjustable fan-blast removes the husks from the machine. From the elevator the grain passes over a screen which keeps back the unhusked grain, and the same is returned to the alternate hopper.

Fig. 3587.



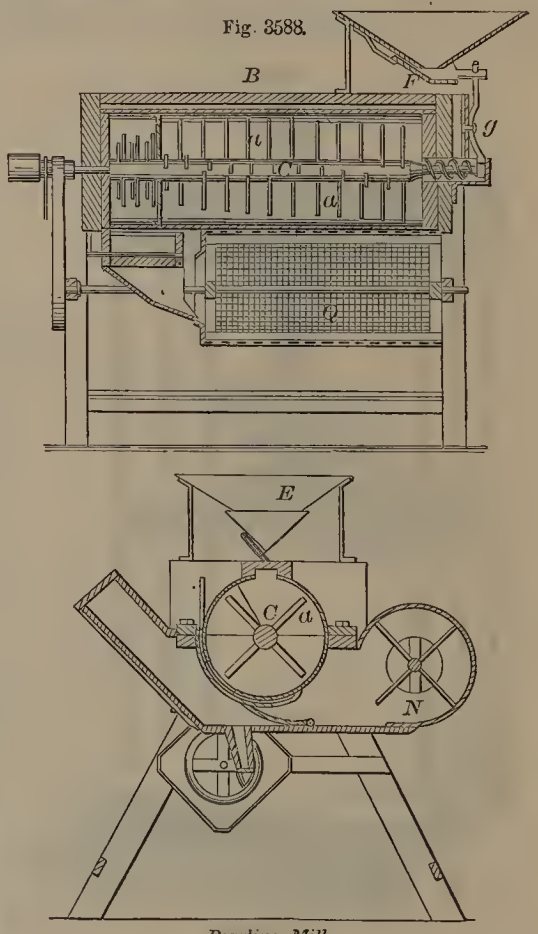
Pearl-Barley Machine.

Pearl-but'ton. A button made of a shell. The blanks are cut out by a revolving steel tube with a serrated end; it forms an annular saw, like a *crown* or *trepan* saw. The blanks are then split by taking advantage of the laminar structure of the shell, placed in a spring chuck, faced and backed by a turning tool, drilled, and polished by rottenstone and soft-soap.

Pearl'ing-mill. A mill for preparing hominy, pearling barley, etc.

The grain is fed from a hopper *E*, and passes down an incline

Fig. 3588.



Pearling-Mill.

F into the spout *g*, whence a screw conveys it into the cylinder *B*, which contains a rotary shaft *C* provided with spiral arms *a a*, by which the grain is beaten and gradually conducted to an opening at the other end of the cylinder, where it is exposed to the action of an air-blast from the fan *N*. It thence passes down the spout *P* to the screen *Q*. See HOMINY-MACHINE.

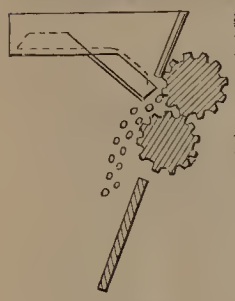
Pearl-pow'der. 1. A submuriate of bismuth, used as a flux for certain enamels.

2. A cosmetic of various compositions.

Pearl-white. A cosmetic. The submuriate of bismuth, obtained by precipitation from nitrate of bismuth.

Pease-meal. (*Foundry.*) Pease-flour, dusted on as *facing* on molds for brass-work. Used also sometimes to give tenacity to very weak sand when strong sand is not to be had.

Fig. 3589.



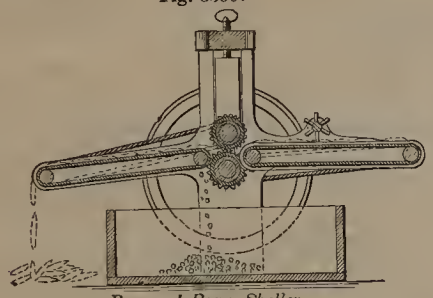
Pea-Sheller.

Pea-shell'er. (*Domestic.*) An implement for taking garden pease from their pods.

The sectional view (Fig. 3589) shows one form. The corrugated rollers grasp and burst the pod; the pease fly out, and the pod is carried away by the rollers. Brushes remove particles of pods from the rollers.

In Fig. 3590 the pods are fed by a belt between the elastic surfaces of two rollers, which burst them open, allowing the pease to fall into the tray while the empty pods are carried off by a discharging belt.

Fig. 3590.



Pea and Bean Sheller.

Peat. A carbonaceous substance formed by the decomposition of vegetable matter when the conditions as to temperature and moisture are favorable. The better qualities contain, when dried, from 45 to 50 per cent of carbon, the remainder consisting of water and inorganic substances; about half the water is chemically combined with the peat. It occurs but in small quantities or not at all in countries where the summer heat is so great as to cause rapid decomposition, and is largely found in such countries as Ireland, Holland, and North Germany, where the summer temperature is low and the air generally moist; the deposits frequently forming extensive bogs, called in Scotland and the North of England "mosses."

In Ireland it is popularly known as "turf," and forms a principal source of fuel supply to the inhabitants, being merely cut into blocks which are dried in the air.

The peat of Ireland is estimated at 4,000,000,000 tons, and is used for fuel and for the production of naphtha, paraffine, etc.

The peat of Holland is deposited on the bottoms of ponds and lakes, — this may be equally true of peat-beds in general, — and is dredged up and spread on the ground to dry. After draining, it is consolidated by the pressure of flat boards fastened to the feet of men who walk over it. It is then cut into blocks and dried for fuel.

Peat forms an ingredient in many of the artificial fuels, being associated with coal-screenings, coke-dust, charcoal, cinder-siftings, pitch, sawdust, spent tan-bark, tar, crude petroleum, asphaltum, wood-shavings, corn-cobs, and other ingredients, in various quantities. Excepting as to the machinery involved, the question is a little outside of our limits.

Peat is prepared for use as fuel, —

1. By drying it in stacks in the open air, or better in sheds, where it is protected from rain but has free access of air. Air-dried peat contains 25 per cent of water.

2. By kiln-drying.

3. By compression. This has the effect of rendering it more compact and increasing the heat yielded by a given bulk. The compression assists the drying. Owing to the fact that peat is not homogeneous, the process of compressing peat in its natural state is a difficult one. It is consequently usually ground and lixiviated with water, to remove the mineral impurities previous to pressing. Various modes of effecting this are practiced in France, Holland, and Germany. These effect a very considerable reduction in the weight of the prepared material, but are objectionable on account of the addition of water, which has again to be dried out of the mass.

In the dry-compression process of Gwynne and Exter, the material is first deprived of its natural excess of water by means of a hydro-extractor, then pulped and dried; the product is then ground into powder, which is molded by pressure, heat being at the same time applied.

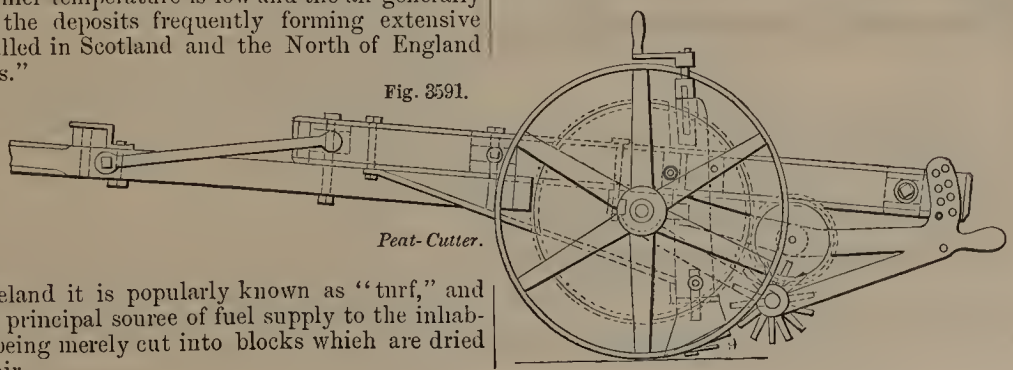
In another process the peat is dried in the air, ground to a coarse powder, then stove-dried, and finally pressed and molded.

The Lester and Halstead artificial fuel is composed of 60 to 65 per cent of peat, about 20 per cent of anthracite dust, 10 per cent coal-tar, 5 per cent asphaltum, but varying in proportion for different purposes, whether metallurgical, domestic, or other. The peat, dug in the usual manner, is laid in the air to dry; and when dry enough to be mixed with the other materials into an amalgam, it is put into a press, and with one blow compressed. Next day it is ready for use.

Peat-burn'ing Fur'nace. Three furnaces adapted for this fuel as well as coal are Bennett's, Washburn's, and Stillman's, described under AIR-ENGINE, page 39.

Peat-cut'ter. An implement of the nature of a plow or excavator, used for paring peat from the

Fig. 3591.



Peat-Cutter.

upper surface of the stratum, for the purpose of treatment in the peat-machine.

The example shows a wheeled vehicle having a transverse slicing-knife 9, which, by the force of the draft, cuts and raises a broad belt of peat; this is delivered from the serrated rear edge of the apron behind the knife to the toothed breaker, which is revolved by gearing from the drive-wheels, and tears the peat to pieces.

Peat-ma-chine'. A machine by which peat, either alone or in combination with other inflammable materials, as coal-dust, is prepared for fuel.

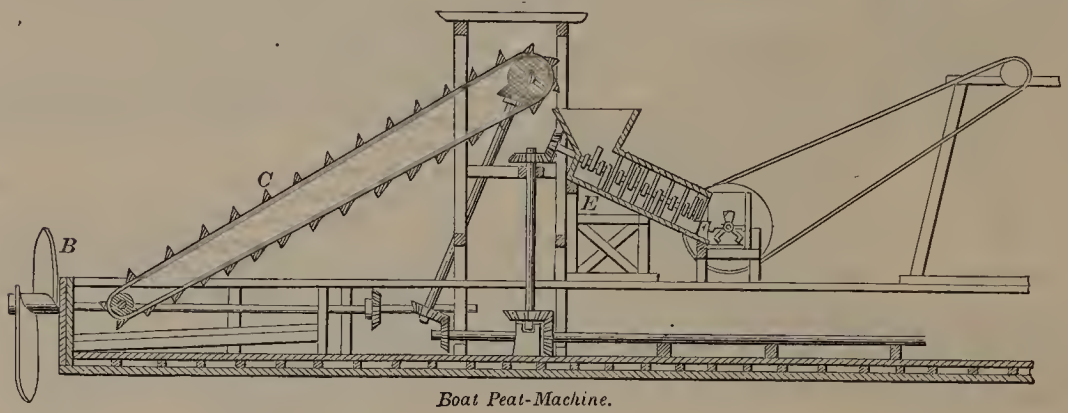
A large number of these machines has of late years been patented in the United States. These are more or less complicated, according to their special function, some being merely designed to cut the peat or to cut and break it, while others perform the whole series of operations by which it is delivered in the form of a densely pressed cake ready for drying and burning.

A few representative examples are shown.

Most of the peat-machines are merely grinders and pressers, which deliver the comparatively homogeneous and dry material in blocks. These machines are so like *brick-machines* that it would appear like duplication to repeat them here. See BRICK-MACHINE.

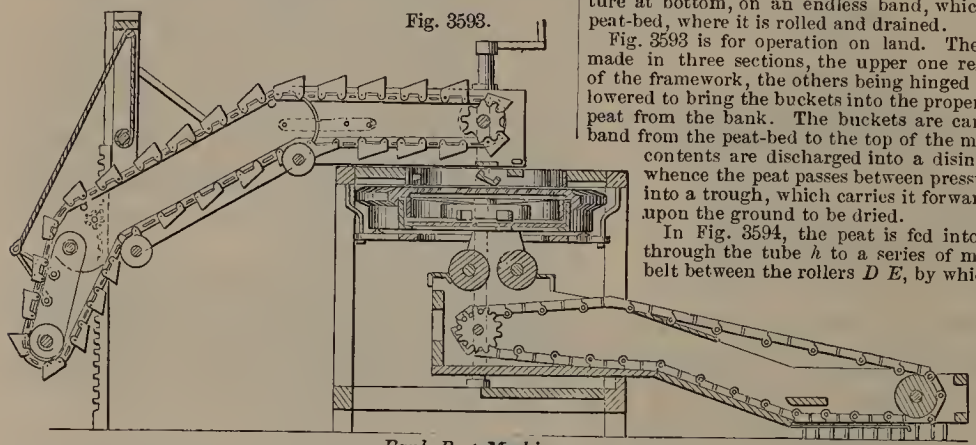
In Fig. 3592, the peat is cut by the screw-excavator *B* and delivered on to the endless belt *C*, by which it is carried to a hopper, where it is fed into the pulping-trough and separator *E F*. This is separated into communicating compartments, and has a shaft provided with radial arms by which the peat is comminuted, afterward passing into the pulping and distributing trough, which also contains a rotating shaft with radial arms, by which it is farther pulped, and deposited through an aperture at bottom, on an endless band, which conveys it to the peat-bed, where it is rolled and drained.

Fig. 3592.



Boat Peat-Machine.

Fig. 3593.

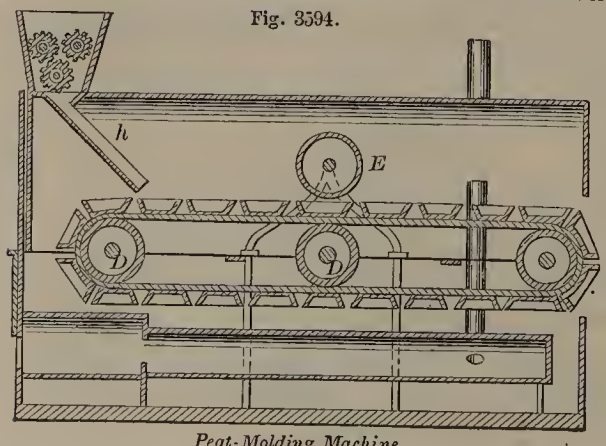


Bank Peat-Machine.

Fig. 3593 is for operation on land. The conveyor-frame is made in three sections, the upper one resting upon the top of the framework, the others being hinged so as to be raised or lowered to bring the buckets into the proper position to dig the peat from the bank. The buckets are carried by an endless band from the peat-bed to the top of the machine, where their contents are discharged into a disintegrating mill, from whence the peat passes between pressure-rollers, and falls into a trough, which carries it forward and distributes it upon the ground to be dried.

In Fig. 3594, the peat is fed into a hopper, passing through the tube *h* to a series of molds on an endless belt between the rollers *D E*, by which it is compressed into cakes; these are delivered from the molds at the rear end of the machine.

Fig. 3594.



Peat-Molding Machine.

Peb'ble. By custom, a lens made of rock-crystal.

Peb'ble-pav'ing. Pavement laid with pebbles from 3 to 4 inches deep. When larger stones are used, it is known as *bowlder*-paving, and is from 6 to 9 inches deep.

Peb'bling. (*Leather.*) An operation to bring out the grain of leather and give it a roughened or ribbed appearance. Formerly, the skin was doubled upon itself with the flesh side outward, and the contacting surfaces rubbed to and fro upon each other until the desired appearance was obtained; or a ball of suitable material, grooved or ridged, was passed over the hair side in various directions.

In the *pebbling-machine*, the skin is subjected to the action of a roller with a surface the reverse of the grain or pebble to be produced. This grain may be an imitation of some more costly piece, and skins with a peculiarly fine grain are sometimes electrotyped, to transfer the design with more fidelity to the roller. The machine has the roller

mounted on an oscillating arm, after the manner of the tool shown in LEATHER-POLISHING MACHINE (which see).

Peck'er. 1. (*Telegraphy.*) A *relay*. So called in England from the appearance of the earlier apparatus, which *pecked* like a bird.

2. (*Weaving.*) The *picker* of a loom. The shuttle-driver.

Peck'ings. *Place-bricks*, from the outside of the kiln and insufficiently burned. *Sandel* or *semel* bricks.

Ped'al. (*Music.*) A lever or key actuated by the foot. In the piano, the soft pedal shifts the *bank of keys*, so that the hammers do not strike all the keys of the *course of strings*. The other pedal raises the damper so as to allow a more sonorous vibration of the strings.

In the organ, the pedals open and close certain pipes. In the parlor-organ or melodeon, the pedal works the bellows.

When it is used in machinery, as in working a lathe or a sewing-machine, it is called a *treadle*.

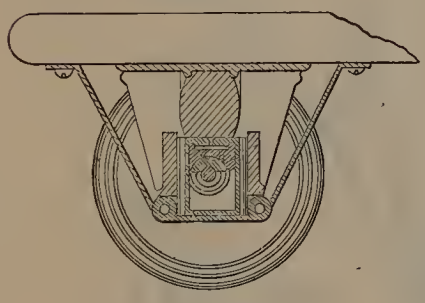
Pedals were first used on organs. (See ORGAN.) About the middle of the eighteenth century they were adopted as a means of working the *stops* of the harpsichord. These were known as the *forte*, *soft*, and *buff*. See STOP.

Ped'al-key. (*Music.*) The *pedal*-keys of an organ are worked by the feet, the *manual*-keys by the hand.

Ped'al-or'gan. (*Music.*) That part of a large organ which is played by foot-keys, enabling the larger pipes to be operated by the feet of the performer.

Ped'es-tal. 1. (*Machinery.*) The standards of a pillow-block, holding the brasses in which the shaft turns. See PILLOW-BLOCK.

Fig. 3595.



Pedestal.

2. (*Railroading.*) A casting secured to the truck-frame and having vertical guides for the journal-boxes of the axles, which rise and fall in the pedestals as the springs collapse and expand.

3. A pillar, post, or column.

4. A plinth, base, or foot for an object to be raised and displayed. When perfect in its parts, it consists of a *base*, *die* or *dado*, and *cornice*. A stylobate.

Ped'es-tal-cov'er. (*Machinery.*) The cap of a pillow-block, which is fastened down upon the pedestals and confines the *boxes*. See PILLOW-BLOCK.

Ped'i-ment. (*Architecture.*) A triangular structure at the termination of a roof, or over a portico, window, or doorway, differing from a mere gable in having a horizontal and two raking cornices, inclosing a tympanum.

Ped'i-ment-ba-rom'e-ter. A barometer whose case is surmounted by a pediment for the purpose of ornamentation.

Pe-dom'e-ter. A *pace-measurer*. An instrument to count the steps.

One form consists of a string with a piece of lead at the end, and knotted at distances of 44 feet apart. It is to be used in connection with a seconds watch. Forty-four feet bears the same relation to an English statute mile (= 5,280 feet) that $\frac{1}{2}$ minute does to an hour; that is, the knots are $\frac{1}{120}$ of a mile apart. Drop the lead and allow the string to pass through the hand, the number of knots slipping through the hand indicate the rate of walking in the number of miles per hour.

Small *pedometers*, to be worn on the person, consist of a train of wheels in a small case, and a dial which registers the number of impulses derived from a cord attached to the foot. In this form it becomes a register of the number of *paces*.

Payne's *pedometer* (English patent, 1831) was of the form and size of a common watch, having a pendulum which was swayed by the movement of the person in walking; the pulsations being registered in the usual way and shown on the dial. The patentee also attached his pedometers to an ordinary watch, in which case the train of wheels and other parts are placed under the dial-plate or face of the watch.

Pee. The point of an anchor-arm which penetrates the ground. The *fluke* or *palm* is the expanded portion which affords an area of holding surface. The *bill*.

Peek. (*Nautical.*) The upper end of a fore-and-aft sail, sprit-sail, etc.; or the outer end of a gaff. See PEAK.

Peel. 1. (*Bakery.*) A wooden shovel with a long handle, used by bakers in putting in and withdrawing loaves to and from the oven.

Fig. 3596.

Peels.

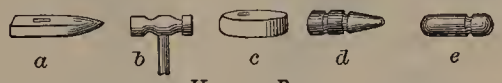
2. A similarly shaped implement for hanging wet sheets of paper on lines or lath to dry.

3. (*Nautical.*) The *wash* of an oar. The end inside the gunwale is the *loom*.

Peel'ing-i'ron. A shovel-shaped thrusting-instrument whereby bark is loosened and pried away from the wood. See BARKING-TOOL.

Peen. The sharp point of a mason's hammer. Sometimes incorrectly written *pane*.

Fig. 3597.



Hammer-Peens.

a, narrow peen for riveting.
b, broad peen for machinists.
c, cross peen for coopers.
d, cone peen for chasing
e, ball peen; upsetting hammer for engravers.

Peg. A wooden nail or pin.

1. (*Shoemaking.*) A small pin of wood (maple) for securing the *upper* and *counter* to the *sole* of a boot or shoe; and for securing the extra *sole* to the upper one, or the *lifts* of the *heel-tap* to each other in *building-up* the heel.

Copper-wire pins have been substituted; also small pins of leather; also screw-pegs.

The term gives rise to many compound words, — pegging-awl, peg-making machine, peg-driver, peg-float, peg-cutter, etc.

Fig. 3598 shows a number of different kinds: —

a has pegs glued to paper, so as to admit of being fed in a ribbon.

b shows a plain and a notched peg, which is designed to be saturated with shoemaker's wax.

c is a peg-strip in which a ribbon of wood is cut out with one sharp edge, the pegs being separated therefrom in the pegging-machine by a chisel and driven by a blow.

d d' d'' d''' are pegs of condensed leather, nearly separated but adhering sufficiently to be fed as a strip.

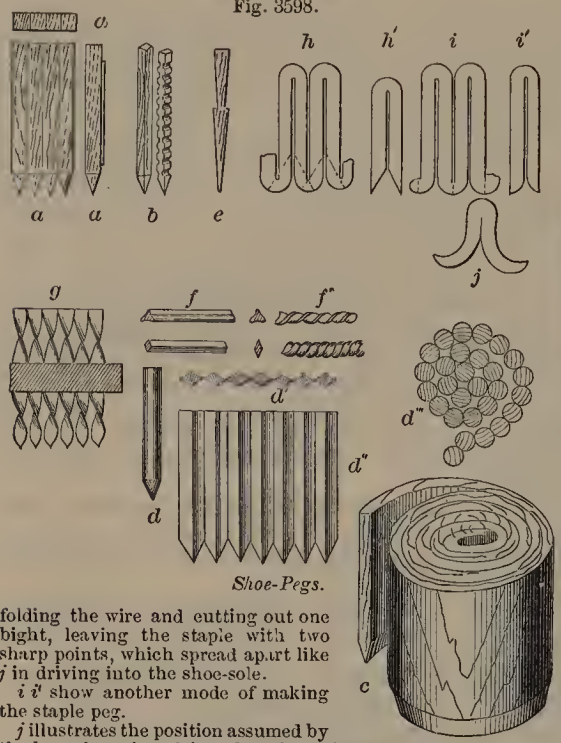
e is a barbed peg.

f f' are pegs made of wires of various angles and twisted.

g shows a row of cable-screw pegs soldered on to a metallic ribbon for feeding in a pegging-machine.

h h' are modes of making staple pegs for boots and shoes by

Fig. 3598.



Shoe-Pegs.

folding the wire and cutting out one bight, leaving the staple with two sharp points, which spread apart like *j* in driving into the shoe-sole.

i i' show another mode of making the staple peg.

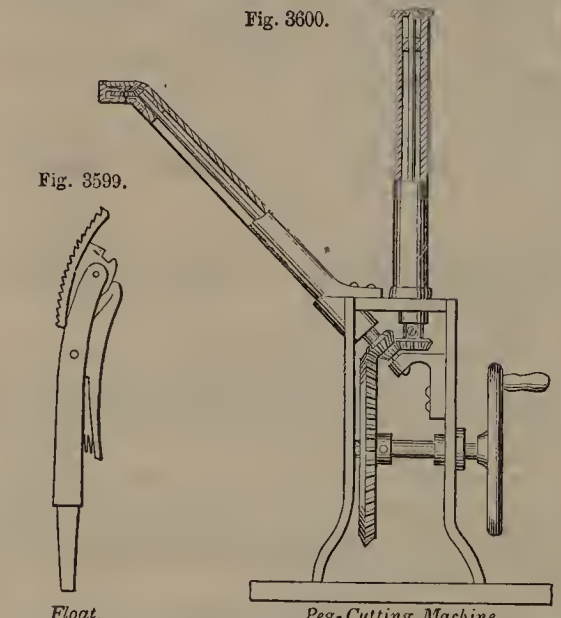
j illustrates the position assumed by the branches when driven by a blow from above.

2. (*Music.*) A turn-pin on which a string of a musical instrument is stretched.

Peg-cut'ter. An instrument or machine for removing the ends of pegs from the insides of boots and shoes. A *float.* In the example this is pivoted in the stock and has a flange beneath, in one of whose notches the spring dog is engaged to main-

Fig. 3600.

Fig. 3599.



Float. *Peg-Cutting Machine.*

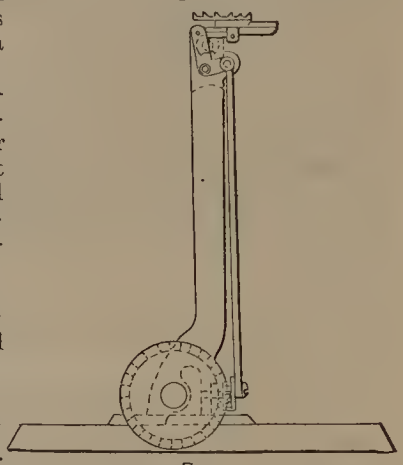
tain the *float* in the required angular position. The stock stands in a hole in a bench.

In Fig. 3600, the cutters at the ends of the shaft have a rotary motion, imparted by gearing and a hand-crank.

Peg-float. An implement for rasping pegs from boots and shoes. In the example, the cutter, instead of being worked directly by hand, is reciprocated by a crank-wheel, connecting-rod, and elbow-lever.

Peg'ging-awl. (*Shoemaking.*) A stiff awl with a four-sided blade, approximating the shape of the peg which is to occupy the hole. It is driven by a hammer.

Fig 3601.



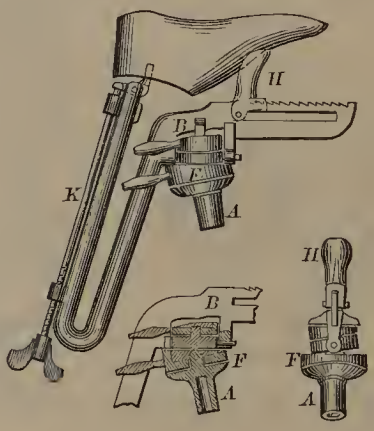
Float.

Peg'ging-jack. An implement for holding a boot or shoe and varying its position while being pegged.

In the example, the latter object is effected by varying the position of the curved arm on the standard *A* by means of cams with handles *B F.* The adjustable pad *H* supports the forepart of the last, while the heel may be tipped by means of the threaded rod *K.*

Peg'ging-ma-chine'. An apparatus for driving the pegs which unite the soles and uppers of boots and shoes. The pegs are usually cut from what is called a peg-strip, which is a ribbon of wood,

Fig. 3602.

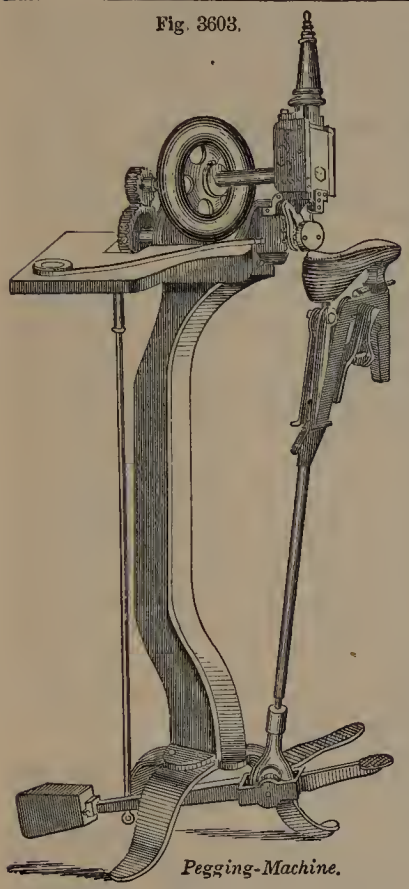


Pegging-Jack.

the grain running across the width of the strip, and fed to the parts which cut off a peg and then drive it.

In the illustration, the long jack-standard is hinged by a universal joint in the foot-lever, which is weighted at one end to hold the shoe in contact with the pegging and feeding devices, and at the other with a stirrup or foot-rest to disengage the finished shoe. The jack is capable of lateral and longitudinal motions upon the standard, to present the surface of the sole at the point of contact with the pegging-devices in a horizontal plane. The vertical plunger, carrying an awl and a driver, is operated by a cam and gearing. The rotary feed is immediately back of the peg-guide, and operated by a pawl and ratchet receiving motion from the main gearing in any suitable manner, ordinarily by a cam. The peg-strip is fed into the guide from a coil of practically indefinite length and from which a peg is cut

Fig. 3603.



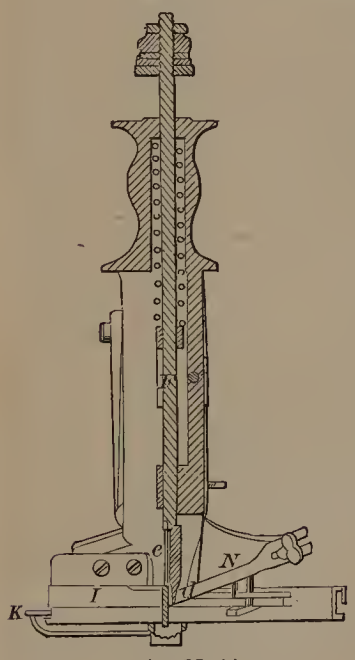
Pegging-Machine.

at each fall of the driver, by a lateral knife, immediately before being driven into the shoe. The long jack-standard brings the mechanism near the eye of the workman.

The two requisite conditions are that the point of contact of the shoe-sole with the pegging-devices must be the center of motion of the work for the time being; and, secondly, the surface of the sole at the point of contact with the pegging-machine must be kept in a horizontal plane.

In Goddu's (Fig. 3604), the awl *e* and peg-driver *d* are simultaneously operated by a spring actuating the plunger *F*, to which they are both attached. The strip of pegs, placed in a feed-trough *I*, is advanced by a follower *K*, and each peg is separated by a flexible knife *N*, which also holds it in position for being driven.

Fig. 3604.

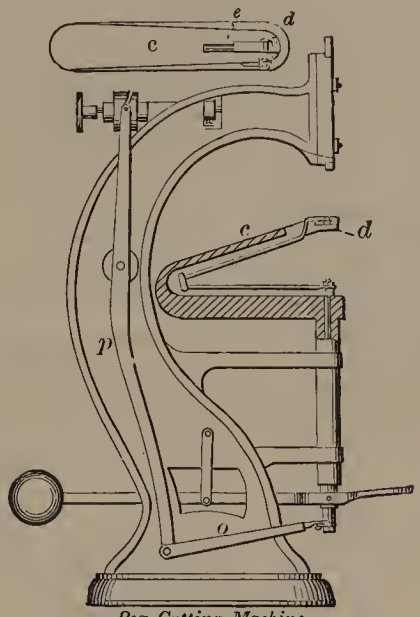


Pegging-Machine.

The device, Fig. 3605, is for cutting off the projecting ends of pegs within the shoe during the process of pegging. The shoe-supporting horn *c* has a slot *d* in which works a knife *e*, operated by a combination of levers *o p*, the upper member of which has a projecting pin working in a slotted cam-shaft.

Sargent's machine is particularly designed for shoes, of which the uppers and soles are united by screw-threaded wire cut to proper length during the operation of pegging. This is effected by a circular cutter connected with a rock-shaft. As the nails are cut off they descend through a peg

Fig. 3605.

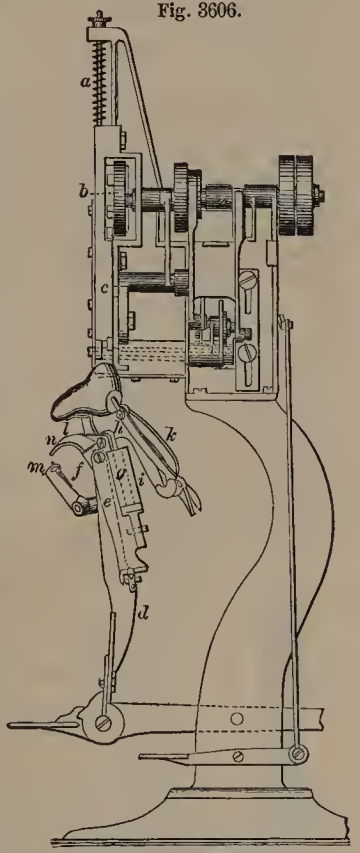


Peg-Cutting Machine.

tube, assuming a vertical position, and are driven home by a plunger actuated by a spring *a* and retracted by a pin on the wheel *b* engaging a shoulder on the plunger.

The shoe is advanced the proper distance to drive each nail, by a swing-plate *c*, whose foot is alternately lifted in and out of contact therewith, and is held at the moment of driving by the foot of the peg-tube.

Fig. 3606.



Sargent's Pegging-Machine.

The shoe is fixed on a jack mechanism consisting of: (1) a supporting upright *d* pivoted to the end of a weighted lever, and is so swiveled as to admit of movement both laterally and vertically; (2) jack-holder *e* joined to the upright by a pin *f*, its vibratory movement on the upright being restrained by stops so as to limit the tipping of the last. A spindle *g* projects from the holder on which the jack is mounted, and is supported on a socket piece, allowing free rotary movement of the jack on the spindle; (3) a last-holder *h*, supported directly over the spindle by a screw, and having a curved arm *i* to which the arm *k* carrying the heel-pin is jointed. It has a ratchet and pawl for forcing the last against the toe-piece *l*.

The arm *i* forms a handle by which the operator guides the shoe being pegged, and another handle operated by the other hand has connections which cause the pin *m* to engage a slot in the lip *n*, and serves to lock the shoe in stationary position relatively to the socket-piece, so that the efforts of the operator may be wholly directed to guiding the shoe without expenditure of strength to keep it in position.

Peg'ging-ram'mer. (*Founding.*) A pointed rammer for packing the sand in molding.

Peg-lad'der. A ladder with but one standard, into or through which cross-pieces are inserted. It is usually fixed.

Peg-strip. A ribbon of wood whose grain runs across the strip, and having one end sharpened, so that chisel-edged pegs may be split therefrom in the pegging-machine. The strip is coiled, placed in the machine, and the end fed into the guide. Invented by Sturtevant, 1858. See PEGGING-MACHINE.

Pein. The small end of a hammer. See PEEN.

Pei-ram'e-ter. An instrument invented by Macneil to indicate the amount of resistance offered by the surfaces of roads. It is a clumsy form of dynamometer, being dragged along on the ground. The power required to move it is indicated by a finger on a dial.

Pel'ham-bit. A bit having a flat, direct-acting joint and cheek-pieces, with bridle-rings at the mouth-piece, and a ring or loop upon the upper arm of the cheek and a loose ring on the lower one. It can be used as a curb or for a double cheek-bridle. This name is also given to bits having loose-jointed and port mouths with straight or crooked cheeks.

Pel'i-can. (*Ordnance.*) An old 6-pounder culverin.

Pel'le-tan-jet. An annular jet of steam used as a form of pump to induce a flow of liquid in an opening within or around the said issuing jet. It differs in principle in no substantial respect from the GIFFARD INJECTOR (which see). See also STEAM-JET; ASPIRATOR; EJECTOR.

Pe-lo'pi-um. Symbol, *Pe*. A rare metal.

Pelt. 1. The undressed skin of a beast with the hair on. They may be large or small, but are usually (not always) intended for furs or felting. *Peltry.*

Buffalo, wolf, gray fox, etc., are for robes.

Mink, otter, lynx, marten, sable, black fox, etc., are for wearing furs.

Musk-rat, coypu, beaver, musquash, hare, rabbit, and others, for the fine hair nearest the hide, for the purpose of felting.

Sheepskins with the wool on are also called pelts. When the hair is removed they become mere *skins*. As *tanned pelts* they form mats.

Fig 3307.

Pelvimeter.

2. The ball-leather used in making inking-pads.

Pel-vim'e-ter. (*Surgical.*) An instrument to measure the diameter of the pelvis, principally in the fore-and-aft direction.

The calipers of Bandelocque have blunt extremities, which are placed respectively on the symphysis pubis and the sacrum, about three inches being deducted for the thickness of the mons veneris, pubis, and the base of the sacrum.

Coutouly's instrument is like a shoemaker's foot-measurer, having a sliding lug. It is introduced into the vagina and then separated, so that one projection touches the promontory of the sacrum and the other comes behind the os pubis.

The cut represents King's pelvimeter with feelers half opened. It is introduced into the vagina with the piston drawn back. When in position it is pushed gently forward, which makes the feelers in front diverge, the extent of which is indicated on the piston-rod.

Pel'y-com'e-ter. A PELVIMETER (which see).

Pen. 1. Pens, if the term be held to include all writing instruments, are of two general kinds, those which scratch and those which use an ink. The former are the more ancient, and consisted of a stylus or bodkin made of bone or metal, and employed upon a leaf, a waxed tablet, a sheet of lead, a stone slab, etc.

The instrument by which an ink or pigment is applied consists of a pen or a brush. The pen was made forty centuries since of a reed (*calamus*), which held almost undisputed sway till the sixth century A. D., when the quill (*penna*) came into use. The materials on which the pen was used were bark, leaves (especially palm), linen, papyrus, skins, parchment, and eventually paper.

Job, chap. xix., seems to refer to the above-cited modes of writing. It is rendered in our version: —

"Printed [inscribed] in a book."
"Graven with an iron pen and lead."

Pliny remarks: "At first men wrote upon palm-leaves and afterward on the bark or rind of trees." The Latin words *volumen*, a scroll, *folio*, a leaf, *liber*, the inner bark, a book, are preserved in our language, indicating the form and the character of the material on which the writings of our distant predecessors were executed.

Writing on pieces of palm-leaves was a very ancient practice, and the Cingalese retain it to the present day. Oblong pieces are cut from the large leaf of the tree, and, being made of a uniform size, are neatly strung together with a cord. Many museums and libraries contain Hindoo, Burmese, and Cingalese books of this kind. The mode of writing upon these leaves was by a sharp instrument, a *stylus*. The point scratched through the external cellular matter, which shrank away from the incision, leaving a shallow groove which was made more plain by rubbing a black pigment into the lines so made.

We learn from Pausanias, a Greek topographical writer who flourished in the second century of our era, that the "Works and Days" of Hesiod, inscribed on *leaden plates*, were preserved at the fountain of Helicon in Bœotia down to his time, but were partly obliterated by the effects of wear and time. Hesiod lived about 900 B. C., but how long the plates had been engraved is another matter. Pliny mentions sheets of *lead* and *tablets*, and refers to their use in the remote past.

The Romans also used ivory tablets named *libri eborei* or *libri elephantini*, and Ulpian states that the transactions of the great were usually in a black color on ivory.

A number of engraved bronze tablets of Rome and Carthage are now in the British Museum. Eight bronze tablets were found in a subterraneous cabinet at Gubbio, Italy, in 1444. Seven of them bore inscriptions in Latin and one in Etruscan. The civil, criminal, and ceremonial laws of the Greeks were engraved on bronze tables. The speech of Claudius, on the same alloy, is preserved in the town hall of Lyons, France. The pacts between the Romans, Spartans, and Jews were written on brass. In many cabinets in Europe are discharges of Roman soldiers

written on copper plates. The laws of the twelve tables at Rome were inscribed on oaken boards; then transcribed on ivory tablets and hung up *pro rostris*, that they might be read by the whole people; after approval, they were permanently engraved on bronze and deposited in the Capitol, where a large collection was melted upon the occasion of the conflagration occasioned by that edifice being struck by lightning.

The Cretans also used bronze records.

Among the ancient inscriptions on bronze yet extant are the "Scriptum de Bacchanalibus," Imperial Library; Trajan's "Tabula Alimentaria"; the helmet found at Cannæ with Punic letters, in the museum at Florence, and various others in the Italian museums, containing inscriptions in Etruscan and Latin.

A deed for land, engraved on copper in Sanscrit characters and bearing date about 100 B. C., was dug up at Mongheer in Bengal. The grantor was a Bideram Gunt.

Pliny informs us that such documents were rolled up like a cylinder. Two letters are still preserved which passed between Pope Leo III. and Luitbrand, king of the Longobards. Montfaucon notices an ancient book composed of eight leaves of lead, the outside two forming the cover, and the whole held together by a leaden rod passing through rings at the back of the plates. The book contained mysterious figures of the Basilideans, together with words in the Greek and Etruscan characters.

The writing of the ancient Assyrians was impressed by knives or stamps upon cylinders or prisms of soft clay very carefully compounded and shaped. Some of these are rough, others polished or glazed. The writing is the cuneiform, the letters one eighth of an inch long.

The cylinders of carnelian, chalcedony, etc., were engraved seals by which the terra-cotta records were verified. See SEAL.

The use of wooden tablets covered with wax is closely allied to that of sheet-lead and a pointed stylus, but the product is of a more ephemeral character. The practice was very common in business and friendly correspondence, and also in official matters which did not require to be laid up for record. Such, for instance, is believed to have been the tablet presented by the Roman legate Popilius to Antiochus Epiphanes, ordering him to evacuate Egypt, which he did, as prophesied by Daniel 366 years previously (Daniel xi. 29, 30).

"Make it plain upon tables, that he may run who readeth it" (Habakkuk ii. 2). An allusion to the old system of relay couriers. Not "that he who runs may read," as often said.

The tables referred to by Isaiah and Habakkuk may have been of wood. The civil laws of Solon were recorded on wood, and placed in a machine constructed to turn easily, and called *axones;* such boards were called by the Greeks *schedæ* or *schedulæ;* when covered with wax, *pugillares cerei.* Pliny and other writers refer to the custom. When a number of such boards constituted a series of leaves, they were described as *cera prima, cera secunda, tertia*, etc. *Tabulæ* and *ceræ* are terms used by the ancient jurists as describing written statements and records. See also BOOK.

The reporters who wrote down the speeches in the forum preferred writing on waxed tablets, which required but a scratch of the stylus. No speed could have been effected with a brush and paint in following the Roman orators.

In the Abbott collection of Egyptian antiquities, now in the possession of the New York Historical Society, are a number of these tablets, made like our school slates and used for the same purpose. The middle portion was sunken to protect the writing, which was executed by a sharp bronze stylus upon a coating of black wax spread over the depressed surface. The latter was on both sides like our slates. The specimens were obtained from Abouseer, along with tee-to-tums, dolls, toys, and other evidences that the amusements of the children in the times of the Pharaohs were much like the modern.

Two ancient waxen tablets were discovered a few years since in gold-mines near and in Abrudbányá, in Transylvania. Each consisted of three tablets with raised margins (like a school slate) to protect the wax surface. The sections folded on each other; the middle one had two waxen surfaces; the outer ones but one each, on the inside. The Latin writing on one set of tablets was still visible, and was a copy of a document whose date determined it to be of A. D. 169. The inscription on the inner tablet was in Greek and nearly illegible.

For important purposes, such tablets were carefully inscribed and fastened consecutively by a cord; or for letters, the boards were covered with a linen cloth. In Hanover and Geneva schedules of this kind are yet preserved.

Leaves were also very generally employed in the early stages of society, and with some previous preparation are still in common use in the East.

In the University of Gottingen is still preserved a Bible containing 5,376 pieces of leaf, formed into 45 sheets. A large number of such books, principally Asiatic, are found in various museums.

The Syracusians and Athenians used olive-leaves for writing sentences of banishment upon, — a mode of punishment inflicted upon public men under a cloud in those turbulent republics.

The Balinese, the inhabitants of Bali, an island of the Malay Archipelago, write with a steel point on the *lanter*-leaf.

The sacred books of the Brahmins and Buddhists are written on leaves of the talipát palm (*talipoin*, a priest), which is a mammoth variety, growing as much as 200 feet high and 4 feet in diameter. The sacred fans of the Buddhists are made of its leaves. It lives to the age of a century and blossoms but once. The bloom is thirty feet in length, and at maturity explodes and scatters its seed.

Sir Hans Sloane's museum had more than 20 manuscripts of palm-leaves written in different Asiatic languages.

To leaves succeeded the *liber*, or inner bark of trees; this was united together so as to form a continuous roll, *volumen*, upon which the matter was written.

Skins of animals, parchment, fish-skins, and bones have been used, as existing specimens testify.

Puricelli mentions a grant by the Italian kings Hugo and Lotharis to the Ambrosian church of Milan written on the skin of a fish.

In the history of Mahomet it is recorded that his disciples wrote parts of the Koran on the shoulder-blades of sheep, which they strung together. Arab poetry was not unfrequently inscribed on these *scapulæ*, probably trimmed for the purpose.

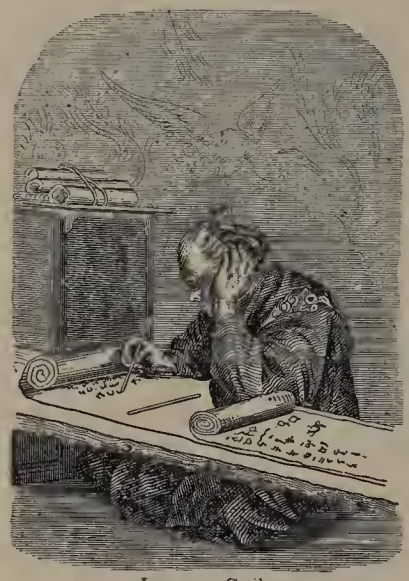
The Alexandrian Library contained the works of Homer written in golden letters on the skins of animals; and the Iliad and Odyssey, written in golden letters on the entrails of animals, collectively 120 feet long, were extant at Constantinople in the reign of the Emperor Basileus. Other instances are known of the use of entrails for this purpose.

Before papyrus became common, the Ionians used instead the skins of sheep and goats, "on which material," says Herodotus, "the barbarians are even now wont to write." Ctesias says he obtained the matter for his Persian history "from the royal parchments" or skins. The invention of parchment is, however, ascribed to Eumenes, king of Pergamos, about 200 B. C.

For notices of papyrus and parchment, see PAPER.

The former instances particularly concern the use of the stylus. That of the *pen* proper will now claim our attention, after we have stated that the *brush* has been used for many centuries in Eastern Asia, and still holds its career of usefulness in forming the Chinese and Japanese letters. It has even been suggested that the brush preceded the pen, as the picture or ideographic writing preceded the phonographic; the language of symbols, that of arbitrary signs denoting sounds.

Fig. 3608.



Japanese Scribe.

The characters of some written languages are well adapted for the brush, and the skill displayed by Chinese and Japanese gentlemen is curious and pleasing to us their neighbors, "upon whom the ends of the world are come," in a sense, for we meet directly by a reverse course the ultimate Orient of our predecessors, ourselves occupying the median line between the new civilizations of Greece, Rome, and their derivatives, and the far older and, to us, fantastic forms of Cathay and the lands thereto adjacent.

Fig. 3609 has two views from paintings at Thebes. The upper figure represents a scribe taking an account of the stock of an estate. It is a part of a much larger picture, in which the shepherds and groups of animals are shown. The scribe is writing upon a tablet; before him are two cases for carrying writing-materials. On his left is the inkstand with black and red ink.

Fig. 3609.

Egyptian Scribes (Thebes).

The lower figure shows a scribe with his inkstand upon the table. One pen is behind his ear, and he is writing with another.

The illustrative history of the Egyptians does not point to a time before the *reed* was used as a *pen*. The various paintings, palatial and sepulchral, show the scribes at work in their avocations, taking the tale of the hands and ears of slaughtered enemies, the numbers of the captives, the baskets of wheat, the numbers of the animals, the tribute, the treaties and public records.

The Egyptian pen of the time of Joseph was a reed, and the scribes used red and black inks, contained in different receptacles in a desk. When this Hebrew viceroy had a small army of clerks and store-keepers employed throughout Egypt in his extensive grain business, his scribes carried their writing-implements in boxes with pendent leather tops, and with handles at the sides. As the scribe had two colors of ink, he needed two pens, and we see him on the monuments of Thebes, busy with one pen at work, and the other placed in that most ancient pen-rack, behind the ear. Such is represented in a painting at Beni Hassan.

It is said that the best reeds for the purpose formerly grew near Memphis, on the Nile; near Cnidus of Caria, in Asia Minor; in Armenia and in Italy: those of the latter being of relatively poor quality. A place yet famous for them, and which may have supplied the ancient demand in part, is in the vicinity of the Persian Gulf, "in a large fen or tract of soggy land supplied with water by the river Helle, a place of Arabia formed by united arms of the Euphrates and Tigris. They are cut in March, tied in bundles, laid six months in a manure-heap, where they assume a beautiful color, mottled yellow and black." (CHARDIN.) Tournefort saw them growing in the neighborhood of Teflis in Georgia. Miller describes the cane as "growing no higher than a man, the stem three or four lines in thickness, and solid from one knot to another, excepting the central white pith." The incipient fermentation in the manure-heap dries up the pith and hardens the cane. The pens are about the size of the largest swan's quills. They are cut and slit like our pens, but have much longer nibs.

A little bundle of ancient pens from Egypt, with the stains of the ink yet upon them, may be seen in the museum of the Historical Society of New York, corner of Second Avenue and Eighth Street. Beside them is a bronze knife used in making the pens. In the East, the reed is yet the ordinary implement for writing.

"When he had finished, he dried the *bamboo-pen* on his hair, and replaced it behind his ear, saying, '*Yak posé*' (That is well). '*Témou chu*' (Rest in peace), we replied; and, after politely putting out our tongues, withdrew." — *Abbé Huc at Lha-Ssa.*

The Christian monks of the land once known as Assyria still use a reed for writing the Chaldean character; the ink has a fine glossy character, the paper resembles parchment, and the scribes dispense with a table or desk, resting the paper on the knee.

Reeds are still used by the Arabs; their ink is thick and gummy. Reed pens are also found in Herculaneum. The ancient ink was of a viscid nature; some of it was found in a closed glass bottle in the examination of the city just mentioned.

The quills of birds came into use as pens in the sixth century A. D.; so we learn from Isidore (died A. D. 636) and others. Previous to this time, the writing-implement is spoken of as *calamus*, a reed; after this we read of *penna*, a feather: the reed, however, was a favorite in many quarters among the literati of Europe for five centuries after the first introduction of the quill. In an illuminated manuscript of the Gospels, executed in the ninth century, the evangelists are represented with quills in their hands. The quills of the swan, goose, eagle, owl, and hawk were used. The preference soon settled on those of the goose for obvious reasons, size and accessibility.

In the sixth century the quill-pen is also mentioned by Aldhelmus, a Saxon poet, who wrote a Latin poem entitled "De Penna Scriptoria."

But a century or so afterward paper was introduced into Europe by the Saracens; first as a curiosity, known as *Charta Damascena*, afterward manufactured in Spain and in Constantinople. See PAPER.

The list of devices by which characters were legibly portrayed by a scratching implement may be thus recapitulated: —

The *tabula* or wooden board smeared with wax, upon which a letter was written by a stylus.
The Athenian scratched his vote upon a shell, as did the lout when he voted to ostracize Aristides.
The records of Nineveh were inscribed upon tablets of clay, which were then baked.
The laws of Rome were engraved on brass and laid up in the Capitol.
The decalogue was *graven* upon the tables of stone.
The Egyptians used papyrus and granite.
The Burmese, tablets of ivory and leaves.
Pliny mentions sheets of lead, books of linen, and waxed tablets of wood.
The Hebrews used linen and skins.
The Persians, Mexicans, and North American Indians used skins.
The Greeks, prepared skins, called *membrana*.
The people of Pergamus, parchment and vellum.
The Hindoos, palm-leaves.

The first attempt at recording was probably what is termed picture-writing. This combines pantomime and numeration, and is found among many savage nations. Instances might be cited from Schoolcraft and from Catlin, and one remarkable example is given from the works of the latter author.

Fig. 3610 shows the robe of Mah-to-toh-pa, the head chief of the Mandans, which consisted of the skin of a young buffalo bull with the fur on one side and the battles of his life emblazoned on the other, by his own hand. It is shown in Catlin's

Fig. 3610.

Robe of Mah-to-toh-pa (Four Bears).

work on the "North American Indians," Vol I. p. 148, and is a good specimen of picture-writing.

It has twelve battle-scenes, showing various fights with Sioux, Riccarees, Cheyennes, and others.

The Egyptian temples and tombs abound with pictures too conventional to be artistic, but so admirably executed that they are bright and sharp even now. The peculiar atmosphere of the country has had something to do with their singularly perfect preservation. Three different forms of writing were used in that wonderful country, — the hieroglyphic, hieratic, and the demotic or enchorial. The first was probably the direct growth of picture-writing, but the characters had attained a certain arbitrary value at the time when the earliest yet existing records were made.

After what we may assume to have been the lapse of many ages, when the phonetic principle was introduced, an alphabet was framed, in which the sound of the first letter of the name of each object was represented by the object, as A by an eagle (*akkem*), M by an owl (*moulag*), etc. The Phœnician alphabet was similarly founded: A, *aleph* (a bull); B, *beth* (a house); G, *ghimel* (a camel), etc. These representations, in the earlier periods of their use, may have been executed with such skill as the artist had at command, and varied according to the talent and taste of the limner; but they afterward became conventional, variations were suppressed, and the portraits of the objects became simmered down to mere symbols.

In Fig. 3611, *a* is a view of a glass bead found by Captain Henvey, R. N., at Thebes. The drawing shows it about two thirds the real size; the inscription is developed on the right, and contains the name in hieroglyphics of a monarch who reigned about 1500 B. C.

b, Fig. 3611, is a remnant of the ages in the shape of a song. It was discovered by Champollion in a tomb at Eilethyas, and is interpreted by him as follows. It reads from right to left, and at the end of the first and third lines occurs the *dacapo* sign, to repeat the line: —

"Thrash for yourselves
Thrash for yourselves
O, oxen!
Thrash for yourselves
Thrash for yourselves
Measure for yourselves
Measure for your masters."

The most enduring of all records is the third in Job's recitation of the modes of writing which may be rendered: —

Written on leaves.
Marked with an iron pen on lead.
Cut into the rock forever.

For many centuries travelers have looked with amazement upon the sculptured buildings of Egypt, Nineveh, Phœnicia, and Persepolis, and upon the inscribed rocks of Behistan, on the frontiers of Media, and the precipice of Van, in Armenia. The solitary monument of Cyrus in the Murghâb, the records of Babylon and Nineveh, of the caves of India, the monuments of Lycia, the tombs of Etruria, the truncated pyramids and portals of Palenque and Uamal in Yucatan, and the broken tablets of Umbria and Samnium, all present riddles of more or less complexity to the students of language.

The setting up of memorial stones was the usual mode of celebrating an achievement or witnessing a pact. Two rival tribes or families set up an altar or build a pile of stones to determine the mutual boundaries of their pastures. A successful warrior made a memorial of his victory in the same manner. The warlike Osymandyas or Sesostris recorded the memory of his marches and exploits. The obelisks of Heliopolis rise to celebrate the return of manly vigor to the convalescent king. Phallic monoliths over the Nile land decently perpetuate the symbols of their religion, and are inscribed with the names and deeds of those who erected them.

Famous in olden times of these lithic monuments are the pillars erected by the children of Seth, as recorded by Josephus, and those erected by the Phœnician Hercules in the environs of Cadiz, monuments of his expedition into Spain. In the time of Demosthenes there was still remaining a column of stone on which the code of laws was engraved. The decalogue was carried in the ark for forty years, and thereafter remained for several centuries in various places, till it was placed in the temple of Solomon. The stones were thence carried as trophies to Babylon.

Engraved gems of the times of the Pharaohs are found among the ruins of the past, and the breastplate of Aaron had twelve stones engraved with the names of the tribes.

The mania for engraving on stones and setting up inscriptions in the wilderness is not dead yet. Missionaries start from the Lama monasteries, year after year, "chisel and hammer in hand, and traverse field, mountain, and desert, to engrave the sacred formula, *Om mané padmé houm*, on the stones and rocks they encounter in their path." They thus carve in Thibetan, Landza, or Tartar characters a prayer of the ages, the yearning of their great religious teacher, Sakya Muni, known as Buddha, the Enlightened, who raised his protest against Brahmanic intolerance on the plains of Nepal some twenty-four centuries since. The formula is from the Sanscrit, which had ceased to be a spoken language in the time of Alexander of Macedon. Its metaphor has been diligently resolved by Klaproth, and, being rendered into English, it means, *O that I may attain perfection and be absorbed in Buddha! Amen.*

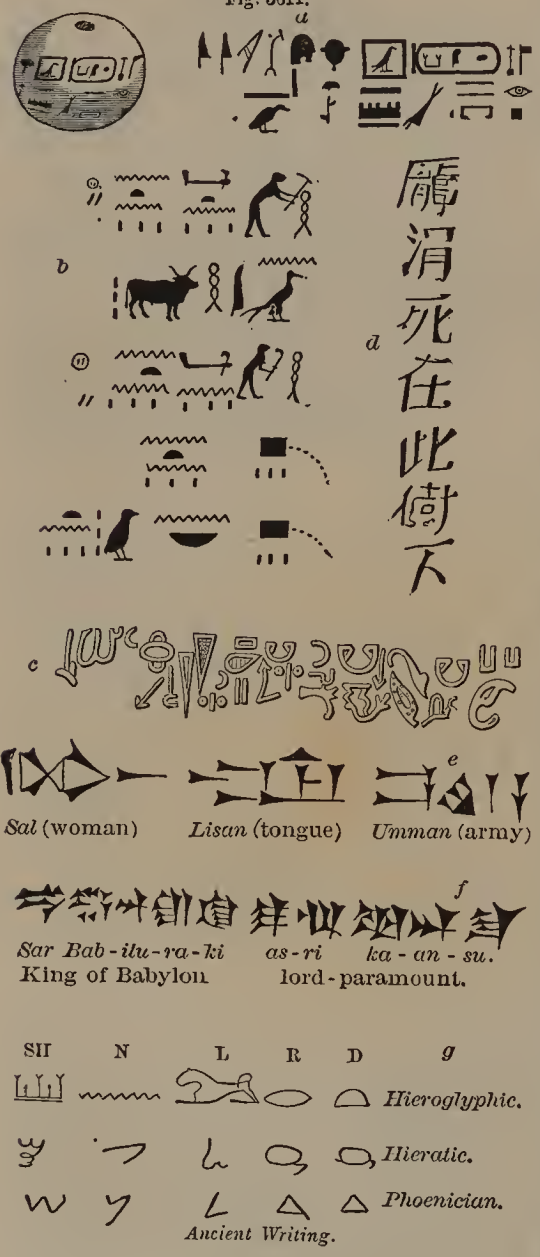
The invading hosts of the Chaldeans left their pictured records on the rocks of Dog River, the ancient Lycus, in Palestine, which here impinges against one of the lofty and abrupt spurs of the mountains of Lebanon. These figures of men are ascribed to the time of Sesostris, and are associated with more recent inscriptions in Persian, Greek, Latin, and Arabic, indicating the presence of the various conquering races by which that country has been suc-

cessively subjugated. Central Asia contains memorials of conquerors of various dynasties.

c, Fig. 3611, is a portion of an inscription discovered at Hamath in Northern Syria. The "entering in of Hamath" is celebrated in the itineraries of these surging nations. No theory of interpretation has yet been advanced for it. In it have been recognized by some, features of the hieroglyphic, cuneiform, and cursive, suggesting that it was a melange of the three, indicating a transition period.

The symbolic writing seems to have taken on two forms: one, the *ideographic*, in which each character comes to represent a word, as in the Chinese,

Fig. 3611.



Ancient Writing.

d, Fig. 3611 (which is said by Du Halde to have developed into orderly characters by 2300 B. C., which is before the time of Abraham); and the most ancient Babylonian, *e*, which Sir Henry Rawlinson calls the Scythic or Accad alphabet. The other variant of the symbolic consisted of cursive expressions of the signs which stood for simple sounds, as stated above of the hieratic Egyptian.

The Scythic is among the earliest known of the *cuneiform*, so called from the resemblance of their characters to arrow-heads. It prevailed in the countries watered by the Euphrates and Tigris, from the earliest historic period down to the conquest by Alexander.

The cuneiform evidently sprang from picture-writing, pictorial representations of objects being made to stand for certain words, eventually without regard to their original ideal signification. From this arbitrary but convenient arrangement came the still farther division by which characters were selected to form a syllabic system, a fixed sign being employed for each connection of a consonant with one of the vowels. There were many hundreds of these signs, representing the consonant and vowel combinations. A phrase is represented at *f*. The varieties of the cuneiform illustrate the progress of the ideographic to the syllabic; the Assyro-Babyloniau is principally ideographic, as at *e*; fewer of these signs are in the cuneiform of the second period (*f*), and its derivative the Armenian; the Persian cuneiform is substantially syllabic. The Hebrew and other languages destitute of vowel indications, as they long were, were practically syllabic.

The cuneiform inscriptions of the Persian monarchs have been resolved by the skill and persistence of Grotefend, Burnouf, Rawlinson, and others. At first they seemed to modern eyes "a mere conglomerate of wedges engraved or impressed." We have now several translations, editions, grammars, and dictionaries of these inscriptions.

The cuneiform writing runs from left to right.

g, Fig. 3611, shows the *hieroglyphic*, *hieratic*, and Phœnician characters representing the sounds D, R, L, N, SH, respectively. The reading is from the right to the left. Points of similarity and relationship are at once apparent. Some of them are fair illustrations of the statement that conventional elisions and modifications have taken place, until the mutilated figure is changed from a portrait to a symbol.

The *hieratic* writing is a short-hand pictorial script, in which the figures are somewhat disguised, and is the basis of true alphabetic writing, in which signs stand for vocal elements.

h, Fig. 3612, is a portion of the inscription on the Moabite stone. This is the oldest Semitic lapidary record of importance yet discovered.

In the summer of 1868, Mr. F. A. Klein, an agent of the Church Missionary Society, made a journey to Kerak, over a country seldom visited by Europeans. On his arrival at Dibân, the ancient Dibon, he was informed by Sheikh Zattam that, scarcely ten minutes from their tent, there was a black basalt stone with an inscription on it. This stone he soon found; it was 3 feet 5 inches high, 1 foot 9 inches wide, had thirty-four straight lines of writing about an inch and a quarter apart, and was rounded to nearly a semicircle at the top and bottom. Mr. Klein took a sketch of a few lines, and went his way, determined if possible to get it removed to the Berlin Museum.

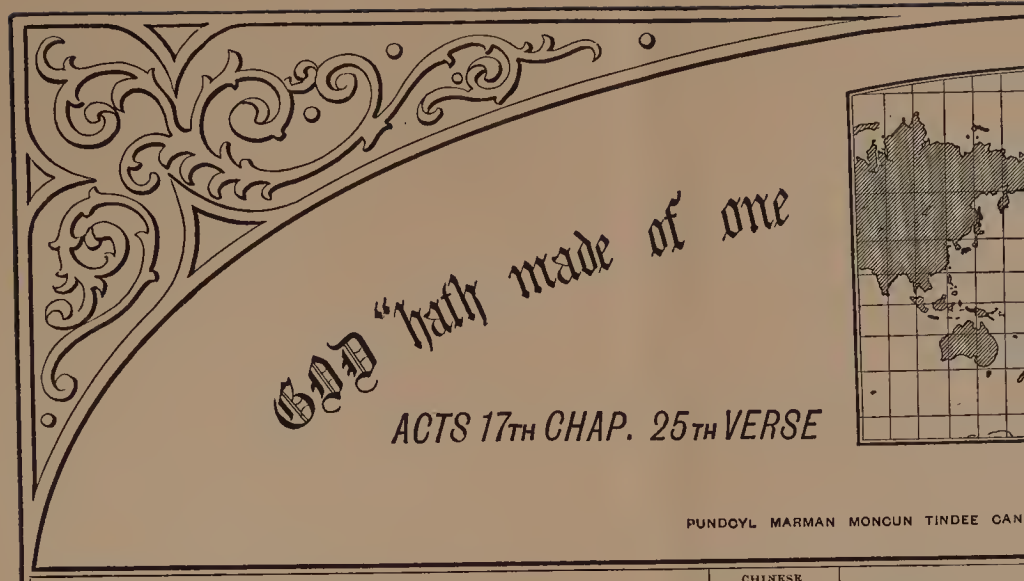
M. Ganneau obtained a few squeezes of the face of the stone before it was broken up by the Arabs, who discovered that it had a market value; strange to say. They made a fire under it and then poured water on it, the villains.

Herr Nöldeke says: "It is *the most ancient memorial of pure alphabetical writing*, much older than any in the Greek. It is the only *original document on the history of Israel* before the time of the Maccabees, and throws light on the relations of Israel with a neighbor much spoken of in the Old Testament."

Until the discovery of this stone, the sarcophagus of Eshmunazar (about 600 B. C.) was considered the most ancient inscription of any length. Here we have a long specimen of the earliest Phœnician character, — the alphabet from which the Greek, the Roman, and all our European alphabets are derived. As Count de Vogué says, these are the very characters which, before 700 B. C., were common to all the races of Western Asia, from Egypt to the foot of the Taurus, and from the Mediterranean to Nineveh; which were used in Nineveh itself, in Phœnicia, Jerusalem, Samaria, the land of Moab, Cilicia, and Cyprus. It disproves the assertion of Aristotle and Pliny that Cadmus only brought 16 or 18 letters from the East into Greece, and that the Greeks invented the rest, for the whole of the 22 are found on this monumental stone.

The Rosetta stone is of 700 years later date. It was found in 1798 by a French engineer in digging the foundations for a fort near the Rosetta mouth of the Nile. It is a tablet of basalt, with an inscription of the year 196 B. C., during the reign of Ptolemy Epiphanes. The inscription is in hieroglyphic, demotic, and Greek.

It was deciphered by Dr. Young, and formed the



FRENCH.
Dieu a fait d'un seul sang tout le genre humain.

SWEDISH.
Gud hafwer gjort allt menniſko flägtet af ett blod.

DUTCH.
God heeft uit eenen bloede het gansche geslacht der menschen gemaakt.

ARABIC.
الله خلق كل اجناس البشر من دم واحد

SPANISH.
De una sangre hizo Dios todo el linage humano.

HINDUWEE.
ईश्वर एक लोहू से समस्त मिनखों के मनुष्यान को उत्पन्न किया है

HUNGARIAN.
Az-Isten az egész emberi nemzetséget egy vérből teremtette.

WALLACHIAN.
Думнезеŭ а фъкът дінтр' ун сінце тот неамул оменеск

GUJERATTEE.
પરમેશ્વર શરવે માણશો આવ્યાત માં તેજ લોહીથી કીધે

BOHEMIAN.
Bůh včinil z gedné krwe wſsecko lidſtí potolenj.

SPANISH BASQUE.
Jaungoicoac odol batetic eguinsuen mundu gustico gendea.

MODERN ARMENIAN.
Աստուած իւրոյ մարդկան ցեղը մէկէն արարած է

ROMANSCH.
Deus ha faig or dad ün saung tut la schlatta d'ils carstiauns.

MODERN GREEK.
Ὁ Θεὸς ἔκαμεν ἀπὸ τὸ ἴδιον αἷμα πᾶν γένος ἀνθρώπων.

MANKS.
Tha Jee er yannoo jeh'n un uill ooilley ashoonyn shelnaue.

PERSIAN.
خدا از یک خون تمام اصناف خلق را آفرید

NEW ZEALAND.
A ka oti i te Atua te hanga ki te toto tahi nga iwi katoa o nga tangata.

COPTIC.
ϕϯ ⲁⲫⲁⲙⲓⲟ ⲛⲥⲩⲗⲟⲗ ⲛⲓⲃⲉⲛ ⲛⲧⲉⲗⲓⲣⲱⲙⲓ ⲉⲃⲟⲗϩⲉⲛ ⲟⲩⲁ ⲥⲛⲟϭ.

SIAMESE
ปวงชีวิต พระ เจ้า ได้ ทรง สร้าง มา แต่ ผู้ เดียว

BENGALEE
ঈশ্বর এক রক্তহইতে সমস্ত জাতীয় মনুষ্যের সৃষ্টি করিয়াছেন।

ANGLO-SAXON.
Lod ȝepophte of ánum blode ealle manna þeoda.

CINGALESE.
දෙවියන්ම හන්සේ මනු සුයන්ගෝ සියලු ජාතීන් එක මංශයෙන් මවුසේක

RAROTONGAN.
Na te Atua i auga i te au tangata katoa i te toto okotai ra.

IRISH.
Dja do ɲiṁe a ṅnile cenél dáoine deiṁḟuil anáiṁ.

BECHUANA.
Morimo rihile merahe eotle ea bathu ka mari a manue héla.

SYRO-CHALDAIC.
ڡڹ ڡڹ ڡڹ ڡڹ ڡڹ ڡڹ ڡڹ ڡڹ ڡڹ ڡڹ.

INDO-PORTUGUESE.
Deos ja faze de hum sangue to do naçaos de gentes.

AMHARIC.
አምላክ : ከንድ : ደም : አሕዛብን : ሁሉ : ፈጠረ ።

MALACASSE.
Andriamanitra efa nanao tamy ny ra iray hiany ny ombelona rehetra.

CANARESE.
ದೇವರು ಒಂದೇ ರಕ್ತದಿಂದ ಮನುಷ್ಯರಲ್ಲಿ ನೆಲ ಜನರನ್ನುಂಟು ಮಾಡಿದನು.

MALAY.
الله ڤرچت سواڠ جوك داره اي سده مكرجاكن سمرا بنس مانسي

ESQUIMAUX.
Gude innagasekauil kinguvangukattiget tamaita pingortilaukpeit aungmn attautsemit.

LAPPONESE.
Jubmel tattam fárt álmatja fiajab aſtat warrast

CHINESE
上帝使人類比旨從一血出。

CALMUC UICHUR

COCHIN-CHINESE
德主至靈沒洲每侌包孕年

Gott hat von eine
Duw a w
Богъ отъ одной
Na te Atu
Икъ вирку
Hatalla djari
Jumala on tehnyt ta
ईश्वर एक
Alla ye mol
GQΦ GΛSKR
Wacinaci amur
Ὁ Θεὸς ἐποίησε
Gud besur
Yalla bind
Deus fe
ईश्वरने मनुष्य
Jain

A PASSAGE OF SCRIPTU

blood all Nations of Men,"

IN 103 LANGUAGES.

KO KOOLCINGEBA BACROOK BAR HOMERCEEK

hen Geschlechter gemacht.

edl o ddynion.

ьхь человѣковь.

i te toto hoc ra.

влямъ инпзинь.

karä djelahad olo.

n yhdestä wereslä.

enolu be dunyato.

hom.

ikirikia abur ite orea.

ν ἔθνος ἀνθρώπων·

dermannanna.

enne rek derreto.

con guciac.

JAPANESE.

(Manchoul) Buriaf

JAPANESE (Literary Cha.)

ITALIAN.

Iddio ha fatto d'un medesimo saugue tutti gli uomini.

DANISH.

Gud haber gjort al Menneſtenes Slægt afeet Blod.

FLEMISH.

Godt heeft uyt eenen bloedt het geheel meuschelyk geslachte voortgebragt.

TURKISH.

الله بتون انسان جنسي برقاندن يارانلي

PORTUGUESE.

Deos de hum sangue fez toda a geraçaõ dos homens.

NEPAULESE.

ईश्वरले एक नीरूदेखि सबै जातका आदमियोंलाइ पैदा गर्‍या

POLISH.

Bog uczynit = iednéy krwi wszystek rodzay ludzki.

SERVIAN.

Отъ крови е,днова произвео Богъ савь родъ чловѣчєскій.

BULGARIAN.

Кѫ̀ созлáлѫ̀ є̃ѿ є̃дна крѫ̀кѫ сичкїатѫ̀ рóдъ человѣ́чєскїй.

LITHUANIAN.

Diewas dáre isz wieno tranjo wissû žmonú gimminès

ENCHADINE.

Deis ha fat our d'un medemm sanng tuot la generatiun humana.

BURMESE.

ဘုရား သခင် သည်။လူ အမျိုး၌း တို့ကို တ ဆွေး သည်နှင့် ပတ်ဆင်း

GAELIC.

Dia rinn e dhàon fhuil uile chinnich dhaoiue.

HAWAIAN.

Na ke Akna no i hana i na lahui kanaka a pau i ke koko hookahi.

OJIBWAY.

Kishemanitoo kukinu beshik miskooing ogiojioshiun kukinu iniuiooun.

HINDUSTANI.

خدا نے ایک لہوسے آدمیون کی سب جاتون کو خلق کیا ہی

MALTESE.

Alla myn demm uŷfied namel koll gens ta bnydmin.

BUGIS.

WENDISH

Boh je zinil ſo wot jenehe krwje ſchittich zlowekow narod

TIBETAN (BAMYIK CHAT)

PIEDMONTESE.

Iddiou a l ha fait d'un sang soul tutta la specie umana.

MALAYALIM.

ALBANIAN.

Περυτία πὲρι γκὰ νιὲβιάκ βίθε φυλίτ' ὲ νιέρεζετ.

BRETON.

Done grëd deus eus a ur goâd hep-ken an holl boblou a dud.

ANCIENT AEMENIAN.

SURINAM NEGRO.

Gado ben meki ala naatsie komopo na da wan broedoe.

ETHIOPIC.

CAFFRE.

U-Tixo wayedalite gegazi linye zonke izizwe zabantu.

TELOOGOO.

ESTHONIAN.

Jummal on teinud ühheſt werreſt teit inimeſte ſuggu.

GREENLANDISH.

Gndib attantsib ãuanit pingort i kei innnperksuit nunamiut tamása.

BULLOM.

Foy ka hallē pang ḿ bull ńkong ah pokan buleing.

D AND THREE LANGUAGES.

See page 1655

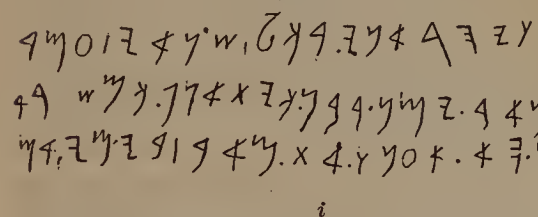
key to the reading of the hieroglyphic characters. It was captured by the English on the defeat of the French forces in Egypt, and is now in the British Museum.

The hatchet, mallet, chisel, square, and saw, all occur among the hieroglyphic characters. *i*, Fig. 3612, shows small portions of the hieroglyphic and demotic inscriptions, respectively.

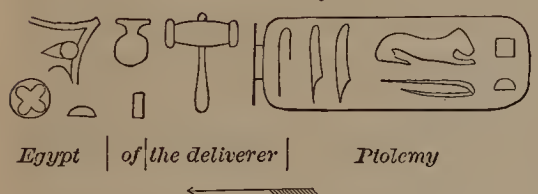
The "Canopus" stone has since added to the fund of knowledge on the subject, and has afforded additional means and subjects for comparison.

"It was through the commercial intercourse of the Ionians with the Phœnicians that the Greeks received the characters of their alphabetical writing, which were long termed Phœnician signs. According to the views which, since Champollion's great discovery, have prevailed more and more respecting the early conditions of the development of alphabetical writing, the Phœnician and all the Semitic written characters, though they may have been originally formed from pictorial writing, are to be regarded as a *phonetic alphabet*, i. e. as an alphabet in which the ideal signification of the pictured signs is wholly disregarded, and these signs or characters are treated exclusively as signs of

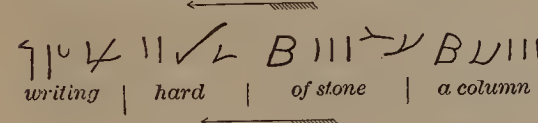
Fig. 3612. *h*



i



Egypt | of | the deliverer | Ptolemy



writing | hard | of stone | a column | On

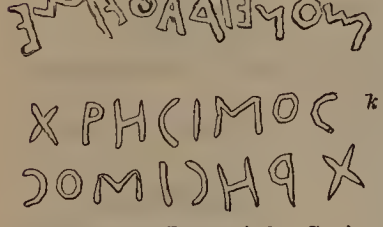
Phœnician, Egyptian, and Greek Writing

sound. Such a phonetic alphabet, being in its nature and fundamental form a syllabic alphabet, was suited to satisfy all the requirements of a graphical representation of the phonetic system of a language." — HUMBOLDT.

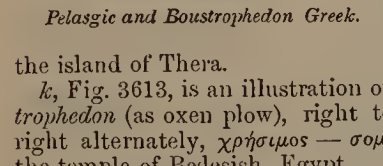
"Phœnicia, mother of the arts,
Letters to learned men imparts."
CRITIAS, *quoted by* ATHENÆUS (A. D. 220).

The ancient Pelasgic, assumed to be the immediate parent of the Greek, was written from right to left, like the Phœnician, whence it came. *j*, Fig. 3613, is an inscription, [Τι]-μων ἐγραφέ με. The letters are Phœnician, as used in early times in Greece. It was found in the island of Thera.

Fig. 3613. *j*



k



Pelasgic and Boustrophedon Greek.

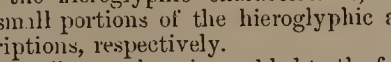
k, Fig. 3613, is an illustration of the writing *boustrophedon* (as oxen plow), right to left and left to right alternately, χρήσιμος — σομσήρχ. It is from the temple of Bedesish, Egypt.

Plate XXXIX. represents the passage, "*God hath made of one blood all nations of men,*" in one hundred and three languages.

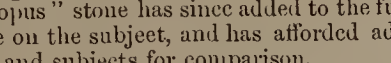
Fig. 3614 shows the same passage in six Asiatic languages. The first of these is written from left to right, the other five from right to left.

Fig. 3614.

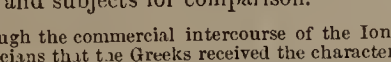
a



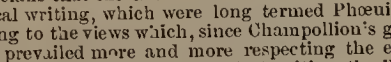
b



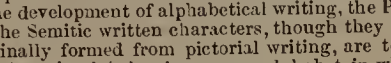
c



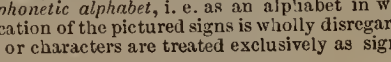
d



e



f



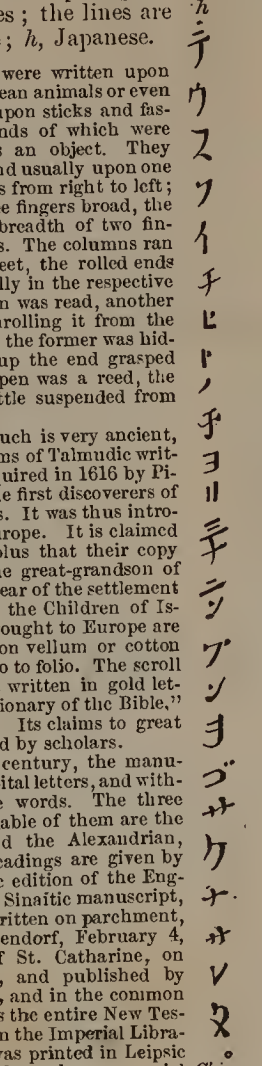
Asiatic Writing.

a, Sanskrit. *c*, Samaritan. *e*, Syro-Chaldaic.
b, Hebrew. *d*, Syriac. *f*, Arabic.

Fig. 3615 shows the same passage in two Turanian languages; the lines are vertical. *g* is Chinese; *h*, Japanese.

Fig. 3615.

h *g*



Chinese and Japanese Writing.

The Hebrew Scriptures were written upon the skins of ceremonially clean animals or even birds. These were rolled upon sticks and fastened with a cord, the ends of which were sealed when security was an object. They were written in columns, and usually upon one side only. The writing was from right to left; the upper margin was three fingers broad, the lower one four fingers; a breadth of two fingers separated the columns. The columns ran across the width of the sheet, the rolled ends of which were held vertically in the respective hands. When one column was read, another was exposed to view by unrolling it from the end in the left hand, while the former was hidden from view by rolling up the end grasped by the right hand. The pen was a reed, the ink black, carried in a bottle suspended from the girdle.

The Samaritan Pentateuch is very ancient, as is proved by the criticisms of Talmudic writers. A copy of it was acquired in 1616 by Pietro della Valle, one of the first discoverers of the cuneiform inscriptions. It was thus introduced to the notice of Europe. It is claimed by the Samaritans of Nablus that their copy was written by Abisha, the great-grandson of Aaron, in the thirteenth year of the settlement of the land of Canaan by the Children of Israel. The copies of it brought to Europe are all written in black ink on vellum or cotton paper, and vary from 12mo to folio. The scroll used by the Samaritans is written in gold letters. (See Smith's "Dictionary of the Bible," Vol. III. pp. 1106–1118.) Its claims to great antiquity are not admitted by scholars.

Previous to the tenth century, the manuscripts were written in capital letters, and without a space between the words. The three most important and valuable of them are the Sinaitic, the Vatican, and the Alexandrian, many of whose various readings are given by Tischendorf in his Leipsic edition of the English New Testament. The Sinaitic manuscript, critically marked *Aleph*, written on parchment, was discovered by Tischendorf, February 4, 1859, in the convent of St. Catharine, on Mount Sinai, in Arabia, and published by him in fac-simile in 1862, and in the common type in 1865. It contains the entire New Testament, and is deposited in the Imperial Library at St. Petersburg. It was printed in Leipsic for the Emperor of Russia, to be a memorial of the thousandth anniversary of his king-

dom. It is in uncial characters, apparently of the fourth century. The Vatican manuscript, marked B, also written about the middle of the fourth century, has been published only since 1857. It is in the Vaticau Library at Rome. The Alexandrian manuscript, marked A, written about the middle of the fifth century, was first published in 1786. It is in the British Museum, at London. The Ephraim or Royal Paris manuscript, marked C, of the fifth century, and the Cambridge manuscript, marked D, of the sixth century, are next in value.

These marks are agreed upon by scholars to designate certain manuscripts.

The enumeration of some of the modes of writing may be interesting: —

The *Mexican* writing is in vertical columns, beginning at the bottom.

The *Chinese* and *Japanese* write in vertical columns, beginning (Fig. 3615) at the top and passing from left to right.

The *Egyptian* hieroglyphics are written in vertical columns or horizontal lines according to the shape and position of the tablet. It is said that with the horizontal writing the direction is indifferent, but that the figures of men and animals face the beginning of the line. With figures, the units stand on the left.

The Egyptians also wrote from right to left in the hieratic and the demotic or enchorial styles. The Pelasgians did the same (*j*, Fig. 3613), and were followed by the Etruscans. In the demotic character, Dr. Brugsch remarks that, though the general direction of the writing was usually from right to left, yet the individual letters were formed from left to right, as is evident from the unfinished ends of horizontal letters when the ink failed in the pen.

In writing numbers in the hieratic and enchorial the units were placed to the left. The Arabs write from right to left, but received their numerals from India, whence they call them "Hindee," and there the arrangement of their numerals is like our own, units to the right.

The Ethiopic and cuneiform characters (*c e*, Fig. 3311) are written from left to right like our own, and this is true of most of the Indo-European languages, while those of Semitic origin are written from right to left. The Phœnician alphabet, the reputed parent of this family, is so written, and the branches include the Chaldaic, Hebrew, Syriac, Carthaginian, Samaritan, Arabic, and Persian characters.

The Pelasgic tribes spoke a language of the Aryan family, allied to the Sanscrit, but obtained their letters from the Phœnicians, and long wrote them from right to left (*j*, Fig. 3613) as in the land from whence they were adopted. The Greek was afterward written *boustrophedon* (as oxen plow), right to left and left to right alternately (*k*, Fig. 3313); in allusion to the usual mode of plowing, before mold-boards and plowing in lands were invented, when the oxen returned close alongside the last furrow made. The laws of Solon were written *boustrophedon*. The later Greek, long before the Christian era, came to be written from left to right like the Sanscrit and the other languages to which it — not its characters — was allied.

The number of letters in the following alphabets is thus given in Ballhorn's "Grammatography," Trubner & Co., 1831: —

Hebrew	22	Ethiopic	202
Chaldaic	22	Chinese	214
Syriac	22	Japanese	73
Samaritan	22	Dutch	26
Phœnician	22	Spanish	27
Armenian	38	Irish	18
Arabic	28	Anglo-Saxon	25
Persian	32	Danish	28
Turkish	33	Gothic	25
Georgian	38	French	28
Coptic	32	German	26
Greek	24	Welch	40
Latin	25	Russian	35
Sanscrit	323		

The letter "J" was introduced into the alphabets by Giles Beye, a printer of Paris, 1660.

Short-hand writing was known to the Greeks and Romans. Its invention was ascribed to Xenophon. It was introduced into Rome by Cicero. Pliny employed a short-hand amanuensis.

The Chinese dictionary shows 43,496 words: of these 13,000 are irrelevant, and consist of signs which are ill-formed and obsolete. For ordinary use 4,000 signs suffice. Kung-fu-tze can be read with a knowledge of 2,500. There are 214 root-signs, so to speak, which indicate the pronunciation, and form *keys* or *radicals*, called by the Chinese *tribunals*. Each character is a word, and the actual number is vastly increased by tones which give quite a different value and meaning.

Quills for pens are assorted into qualities determined by the character of the barrel. They are plunged into heated sand to make the exterior skin peel off and the interior membrane shrivel up. This may be performed, however, by alternate soaking in water and drying before a charcoal fire. They are hardened by soaking in a hot solution of alum.

The yellow color so much admired is conferred upon the quill by a dip into nitric acid.

Iron pens are mentioned by Chamberlayne in 1685.

The first metallic pens regularly introduced for sale were by Wise, about 1803. They were made in *barrel* form, being adapted to slip on a stick, and under the name of *perpetual pen* were industriously distributed throughout the stationers' shops of London. The prejudice was strong against them, and up to 1835 or thereabouts quills maintained their full sway, and much later among people of a conservative cast of mind and in the circumlocution offices here and abroad.

The writer recollects the tedious waiting for the patient usher who passed from desk to desk with his pen-knife, mending pens and paying very little attention to anything else; also the wonder felt and expressed at the first sight of steel nibs, and how they dug into the paper.

Bramah patented *quill-nibs;* made by splitting quills and cutting the semicylinders into sections which were shaped into pens and adapted to be placed in a holder. These were, perhaps, the first *nibs*, the progenitors of a host of steel, gold, and other pens. See PEN-MAKER.

Hawkins and Mordan, in 1823, made nibs of *horn* and *tortoise-shell*, instead of quill. The tortoise-shell being softened, *points* of *ruby* and *diamond* were imbedded. Metallic points were also cemented to the shell nibs.

Doughty, about 1825, made *gold pens* with *ruby points*. See GOLD PEN.

Gold pens with *rhodium points* were introduced soon afterward.

Gillott devoted much pains to the improvement of the material and manufacture. One of his patents was in 1831. See STEEL PEN.

Perry exercised considerable ingenuity in the application of new forms and in developing the elasticity. His patents were in 1830 and 1832.

Mordan's *oblique pen*, English patent, 1831, was designed to present the nibs in the right direction while preserving what most people appear to think the most convenient position of the pen and the hand.

Scheffer's *fountain-pen* was introduced about 1835 by Mordan. The pressure of the thumb on a stud in the holder caused a continuous supply of ink to flow from the reservoir to the pen. See FOUNTAIN PEN.

Parker's *hydraulic pen* (English) has a piston which works up and down in a tube by means of a screw stem and a revolving nut on the end of the holder.

Fig. 3616 shows several forms of pens.

a is a pen with a broad flat nib made for marking packages, for writing placards and show-bills. Ink is retained between the several superposed plates, and the breadth of the nib determines the width of the stroke, unless the pen is turned edgewise.

b is a reservoir pen having fluted sides to lead the ink from the reservoir to the nib

c is the iridium-tipped gold-nib pen, mounted with gutta-percha or hard rubber.

d has wings to hold a globule of ink.

e has a flexible strap around the nibs for the same purpose.

f has a peculiarly bent body to give elasticity and also form a holder for ink.

g has wire below the nib, to hold ink.

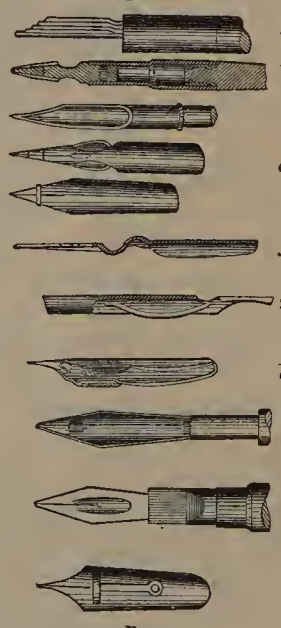
h has bent-over wings for the same purpose.

i has a wire likewise.

j, a depression in the body of the pen.

k, a cruciform piece riveted to the under side of the pen.

Fig. 3616.



Pens.

2. An ink-leg of a compass.

A draftsman's instrument for drawing lines of even thickness, or dotting lines. See DRAWING-PEN.

See GOLD PEN; STEEL PEN; FOUNTAIN-PEN; DRAWING-PEN; RULING-PEN; MUSIC-PEN; DOTTING-PEN, etc.

3. An inclosure of limited size for cattle or hogs.

Pen'chute. A trough conducting the water from the race to the water-wheel.

Pen'cil. 1. A cylinder or slip of marking material, usually graphite, but may be of colored crayon or French chalk. It is usually inclosed in a sheath of cedar, but is sometimes a cylinder or prism of sufficient size to be grasped by the fingers or by a porte-crayon.

The kind of pencils known as lead-pencils is made from *graphite*, otherwise known as *plumbago* or *black-lead*. The latter two names are misnomers, as no portion of lead enters into its composition. See GRAPHITE.

Graphite is a soft variety of carbon, sometimes containing a small proportion of iron. It is found in many parts of the world, but few localities yield it of sufficient purity for making pencils. For many years the best obtainable was from the mine of Borrowdale, Cumberland, England, discovered in 1564. It was locally known as *wad*. This mine gave England the monopoly of the finest quality of pencils, and the amount taken from the mines yearly was strictly limited in order to keep up the price. The annual product was valued at £40,000. This source of supply eventually failed, but the loss was scarcely felt, as a number of other mines had been discovered in various parts of the world.

The ancients drew lines and letters with leaden styles, and afterward an alloy of lead and tin was used. Pliny refers to the use of lead for ruling lines on papyrus. La Moine cites a document of 1387 ruled with graphite. Slips of graphite in wooden sticks (pencils) are mentioned by Gesner, Zurich, in 1565; he credits England with the production. They were doubtless the product of the Borrowdale mine, then lately discovered. In the early part of the seventeenth century, *black-lead* pencils are distinctly described by several writers. They are noticed by Ambrosinus, 1648; spoken of by Pettus, in 1683, as inclosed in fir or cedar.

Red and black chalk pencils were used in Germany in 1450; in fact, fragments of chalk, charcoal, and shaped sticks of colored minerals had been in use since times previous to all historic mention.

Painting of the body, face, and limbs is an accomplishment in all countries where clothing is scanty, and some tribes have ingeniously contrived to make it permanent by tattooing. This art is both ancient and modern, and has its professors in many countries. The name is Polynesian, and among these singular peoples the practice has been, perhaps, perfected. Vagabonds on the fringe of civilization emulate the rites of their ancestors, and naturally recur to the habit of tattooing; hence ships, hearts, true-lovers' knots, and mottoes pricked into the arms and breasts; and hence means of identification equal to the famous "strawberry-mark on the left arm" of the long-lost brother, or, equally famous now, the absence of the tattooed mark on the arm of the spurious Tichborne.

Hans Holbein drew portraits in crayon in 1540. Sir Thomas Lawrence excelled in crayon-drawing during the early part of the present century. Crayons and pencils are used by painters in designing and sketching-in on canvas. The imitation of the chalk-drawing has given rise to one style of plate-engraving, known as the *stipple* or *chalk* engraving.

When Cortez landed in Mexico in 1520, he found the Aztecs using graphite crayons, which were probably made from the mineral found in Sonora.

As has been said, the mounting of the small graphite bars in wood originated in England. The block of graphite was sawed into prisms of the required shape, and of such length as the lump admitted. Each slip of graphite was laid in a groove made in a slip of cedar, a little glue causing it to adhere; another slip of cedar was laid over it, and the pencil was shaped by a round-soled plane. Several lengths of graphite filling were required for the length of a pencil, as the lumps were usually small in size and the pieces very frangible.

To utilize the waste, Mr. Brockedon attempted to compress it into blocks in powerful hydraulic presses, but without much success. The plan of grinding up into a pigment, which was hardened into a block by baking, was afterward introduced with better result.

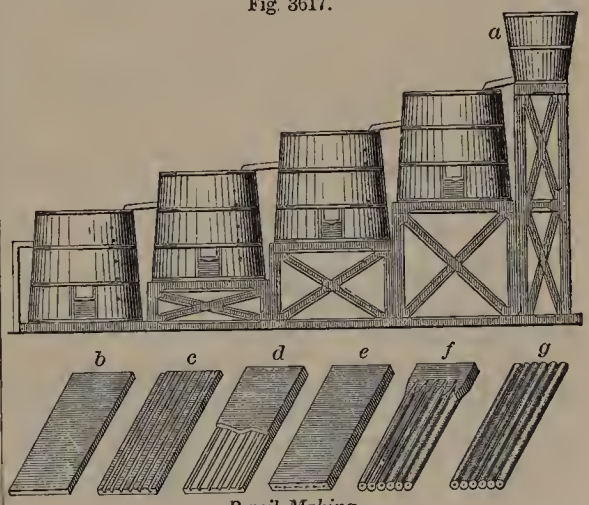
When the Borrowdale mine was giving out, Conté of Paris invented the method of producing the *leads* by making a mixture of graphite and clay, pressing it into the required shape from a mass like dough, and baking it to the requisite hardness for use. All the pencils now made in any part of the world are made by Conté's process.

The following is the method employed by Mr. Cleveland, of the Dixon Company, at Jersey City, in the production of "Dixon's American Graphite Pencils": —

The graphite is purified by various means, according to the nature of the foreign matter it may contain. Ticonderoga graphite ground fine in water is treated with sulphuric and nitric acids, and, after washing clean, heated to a bright red. See GRAPHITE.

It is then mixed with water until thin enough to run very freely, and the mixture turned slowly into the hopper (see *a*, Fig. 3617). The coarser or heavier particles will settle at the bottom of the

Fig. 3617.



Pencil-Making.

first tub, the next heavier in the next tub, and so on, till the water will run almost clear from the overflow of the last tub, as shown in the cut.

For the finest pencils the deposit in the last tub is used, but for the commoner sorts the deposit in the tub next to the last will answer very well, and for ordinary pencils the deposit in the one still before that is used. The stream should run into the first tub very slowly and gently, so that the contents of each tub will be but slightly disturbed.

When the operation has been going on for some time the inlet is stopped, and after leaving the tubs for half a day to settle, the clear water above the deposit is decanted by withdrawing a small pine plug, several of which are inserted in holes bored in the sides of the tubs, at convenient distances from the top, and by drawing out these one at a time as the water gets lower, all the water is decanted without disturbing the deposited graphite, which is very light and will rise with the least agitation, especially that which is deposited in the last tub.

The gates near the bottom of the tubs, shown in the cut, are then raised and the contents removed and dried.

The graphite is now ready for the *clay*.

The clay this company employs is known in market as *pipe-clay*, of a bluish-gray color, has great strength, and is very unctuous and fatty when wet. It comes to this country from Rotterdam for the manufacture of crucibles. The clay is separated in water and floated through a series of tubs in the same manner as the graphite, only the finest part being fit for pencils.

Like the graphite, it is dried before mixing, in order that the mixture may be exact and reliable for the production of the different grades of *leads*. The larger the proportion of clay the harder the grade, and a less proportion of clay and more graphite produces a softer grade. For a medium grade the proper proportion is, 7 parts of clay to 10 parts of graphite, by weight.

Water is added to the clay and graphite, and the mass fairly mixed by the hands to the consistency of thick cream. In this state the mass is fed into the mills for final grinding. The mills are of stone, 24 inches in diameter, only the top stone running, and that at considerable speed. This operation is much like grinding paint, and the mass is passed through these mills many times; for the fine pencils it is ground over as many as twenty-four times before it is considered ready for use. It is now a pasty mass, and this is inclosed in a canvas bag and placed in a powerful steam-press, where the water is pressed out, much the same as oil is pressed out of ground linseed. This pressing is carried to that point that leaves the mixture a stiff dough, ready for the forming-press.

The forming-press is composed of a cast-iron well, 8 inches deep and 4 inches in diameter, inside measure, having a follower or plunger, like an old-fashioned sausage-stuffer. The material is molded into the shape of the inside of the well, by working it with the hands as the potter works his clay, placed in the well and driven snug down with a hammer and wooden plug; the iron follower then comes down slowly, driven by a powerful screw.

In the lower end of the well, which is upright, is an opening of the exact size and shape, square or round, desired for the leads; and as the follower presses upon the material, a thread spins out below and coils itself upon a board placed underneath to catch it. A sufficient quantity being spun out for convenient handling, the board is removed and another put in its place. From this coil the *lead* is drawn off and straightened out upon boards of suitable length for three pencils, the back edge of the board having a raised straight-edge against which the first length is placed, the next length laid snug against the first, and so on till the board is full, when it is placed carefully away for the leads to dry. When dry they are very brittle, and are cut into lengths for pencils, placed upright in crucibles of graphite, made for this use, with straight sides and fitted with covers.

When the crucible is full the leads are covered over with fine graphite to exclude the air, and as a farther precaution the cover of the crucible is well luted on. The crucibles are then heated to a red heat, taken out of the oven and cooled, and the leads removed ready for use.

The next step is the preparation of the wood. Only a soft, close-grained wood will answer, and the best is the Florida cedar.

The wood is sawed into pieces *b* of the right length for a pencil, of a width suitable for six, and of half the thickness for pencils.

These blocks run through a machine that planes and grooves them (*c*), the grooves being the depth of half the size of the leads. The leads are then laid into the grooves of one piece while the other piece of cedar exactly like it is coated with glue and laid on the first (*d*). These double pieces, or blocks, are then placed in a press, many of them together, till dry enough to proceed. Leaving the press they are solid blocks containing six leads equidistant from each other, ready to be shaped into six pencils, and these blocks (*e*, Fig 3617) go through the first machine, that brings them to size, and then through the next machine, similar to a molding-cutter, coming out six pencils from each block. The cut *f* shows the block before it is quite through the machine; *g* shows six perfect pencils.

The machine which converts the block into pencils is of the nature of a planing-machine with a series of circular cutters above and below, like the molding-machines for wood-working. The effect of the upper and lower rows of cutters is, respectively, to cut a series of six beads, the joint effect being to make six cylinders from the block, the parts and positions of the cutters being so accurately gaged as to leave the *leads* in the exact center of each cylinder (or hexagon, as the case may be), and leave no fin or mark upon the edges of the pencils where the action of the upper and under series of cutters meets at the middle of each pencil, as shown in the cut.

The knives in these shaping-machines, in order to do the work well, should revolve at the rate of 4,500 revolutions per minute, and must run absolutely true, as any weakness or tremor will destroy the finish on the surface of the wood, and make it necessary to adopt the old process of sand-papering each pencil, as still practiced by other manufacturers. The finish obtained by the machine is such that sand-paper would roughen them. The round and hexagon or other shapes are produced in the same way. The pencils are now ready to receive the color and finish, according to taste, and are then stamped and packed for market. Great care must be taken to have the wood dry, and it is better air-dried than kiln-dried.

The machine for shaping turns out the pencils from the blocks at the rate of 72 per minute, or over 43,000 per day. The varnishing and coloring of the surface is done by a machine at the rate of 120 per minute, or 72,000 per day, and they are polished by a machine at the rate of 106 per minute, or over 63,000 per day. All of these machines are attended by girls about twelve years of age, one to each, no skilled labor being required.

The granular formation of graphite is more easily prepared than the foliated. The Dixon Company has extensive mines at Ticonderoga and a large mill at the outlet of Lake George into Lake Champlain, where the pure foliated graphite is manipulated very cheaply.

Colored pencils are made in the same way as black, except that the little bars cannot be baked like the black *leads*. Heating destroys the color.

In making them, coloring-matter of the kind desired is used with the clay, instead of graphite, and they are boiled in wax before being placed in the wood.

The Florida cedar is used by all of the principal pencil-makers in the world, on account of its fine grain, softness, and strength combined.

Dixon's American graphite pencils are in different styles, as *black*, *maroon*, *cedar-finish*, the latter being in the natural color of the cedar of which they are all made; *satin-finish*, a new style, is made of the same cedar, but finished to resemble French walnut in color, showing the grain of the wood. There are ten distinct grades of hardness in the leads, shown by the grade stamps, as follows: VVS, *very, very soft*, for the deepest heavy shading. VS, *very soft*, for very deep shading. S, *soft*, for rapid shading in sketching, the softest grade for office use. SM, *soft medium*, for general sketching, the popular grade for office or pocket. MB, *medium black*, for drawing or general use. M, *medium*, for office and stenographic, professional, or desk use. MH, *medium hard*, for finer desk use or fine lines in drawing. H, *hard*, for bank use, or finer lines in drawing. VH, *very hard*, for architects, engineers, draftsmen, etc. VVH, *very, very hard*, for the finest lines.

The S, SM, M, H, and VH are the five regular office grades. The whole ten grades are for artists. The SM and M only are made in the round black pencils with the gold stamp, and in the maroon finish both round and hexagon shapes. But the five regular office grades of leads are all made in round and hexagon shapes, in both the *cedar finish* and the new *satin finish*, and the whole ten distinct grades of lead are made of the hexagon shape only, both of these styles of finish, for artists and technical uses.

The old method of sawing them out of solid blocks of graphite produced leads of rectangular shape, and they have been continued in that shape to the present day; but the Dixon Company has introduced round leads in round wood, making a decided improvement. The round leads are more easily sharpened, are stronger than the flat shape, and more in harmony with the exterior of the finished pencils.

Fig. 3618 shows a number of modes of attaching rubber to lead-pencils.

Various convenient additions to pencils have been made, such as attaching calendars thereto, sheaths to cover the leads, thimbles and sockets to attach the pencil to the lappel of the coat or vest. Two pencils in a pair of sheaths jointed together make a convenient pair of compasses for many purposes.

The *pencil-leads* as sold by stationers and jewelers for pencil-cases and ever-point pencils are little cylinders made of graphite and clay kneaded with water until it assumes the consistency of putty. This is placed in a cylinder and forced by heavy pressure

Fig. 3618

Rubber-Tipped Pencils.

through a circular hole in the bottom of the cylinder, the size of the opening determining the size of the lead which is indicated in the trade by a number. The material issues in long flexible threads, which are received on sheets of metal and placed in an oven. The length of time occupied in the baking determines the hardness. The threads are then broken up into short pieces and boxed according to their sizes, Nos. 1 to 9.

2. A small brush or *tool* employed by painters. Pencils are made of camel, badger, squirrel, fitch, or sable hairs.

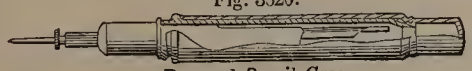
3. To draw a line of white paint along a mortar-joint in a brick wall, to render the joint more conspicuous and contrast with the color of the bricks. This is termed *penciling*.

Fig. 3619.

Pencil-Case.

Pen'cil-case. A holder for a pencil, usually with a slide by which the pencil is

Fig. 3620.



Pen and Pencil Case.

retracted into its sheath to reduce the length of the instrument and preserve the lead from breakage when carried in the pocket.

Fig. 3621.

Ever-point Pencil.

The usual form has a hollow holder from which the tube holding the pencil-lead is projected by twisting or by simply sliding out.

In Fig. 3620, the case consists of a single tube with a screw cap, and a reversible penholder and pencil-point. The tube has also a section extensible telescopically.

In Fig. 3619, the pen is on a sliding piece at one end, while the pencil-holder is socketed in the other end, either projecting for use or inclosed for compactness in carrying-ing.

The ever-point pencil was patented in England in 1823 by Hawkins and Mordan.

The small cylinder of black-lead is pushed forward by a driver, so as to project through the end of the nozzle. On the outside of the driver is a screw, and on the end of the lead-cylinder is a nut, so that when the nozzle is held in one hand while the case is turned by the other, the driver is worked in or out for the reception of another lead or for the driving out of the contained lead, respectively.

Pen'cil-clasp. A device to hold a pencil to the lappel or breast of the coat. Used by import clerks and others.

Pen'cil-com'pass. One having a pencil-end at one leg; or a compass to which an ordinary pencil may be attached, as in the example.

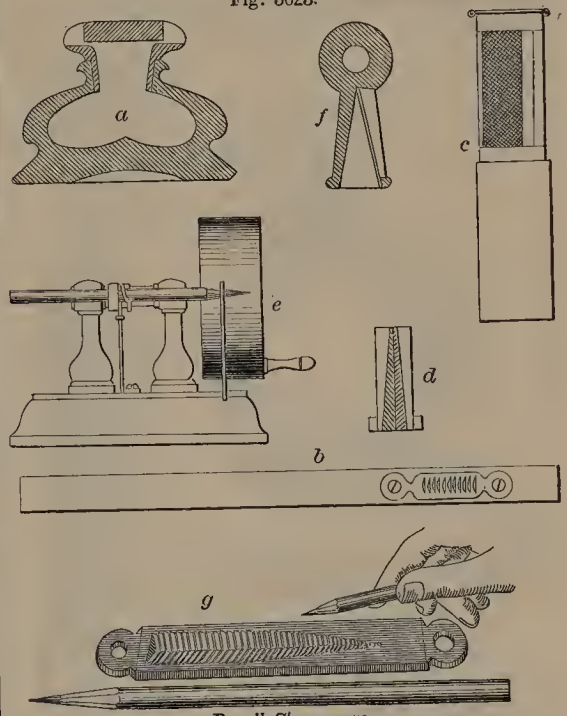
Fig 3622

Pencil-Compass.

Pen'cil-sharp'en-er. A device against which a lead or a slate pencil is drawn or rotated in order to sharpen the point.

For slate-pencils it may consist of a file on a stake, in a cup *a* or on the edge of a slate-frame *b*. The same may answer for lead-pencils if the wood be previously cut away. *c* is a pocket-file which slips into a sheath. *d* is a serrated socket in which the pencil-point is rotated. *e* is a form in which the pencil is held against a rotating wheel. *f* has a blade which will cut wood and lead impartially. *g* is of hardened steel, the groove being serrated.

Fig. 3623.



Pencil-Sharpeners.

Pen'dant. 1. (*Nautical.*) *a.* A strap or short rope depending from a mast-head, and having thimbles for bearing the blocks, which transmit the effects of tackles to distant points. Their names indicate their specific duty; as, *fish*-pendant, *brace*-pendant, *stay-tackle* pendant, etc. Used especially in setting up masts and rigging.

b. (Or *Pennant.*) A long, narrow strip of bunting worn at the mast-head of vessels of war. Playfully called a *coach-whip*, in contradistinction to a *broad pennant*. See PENNANT.

2. (*Architecture.*) *a.* An ornament suspended from the roof of a Gothic or Tudor building; the hanging ornament from the crown of a vaulted ceiling.

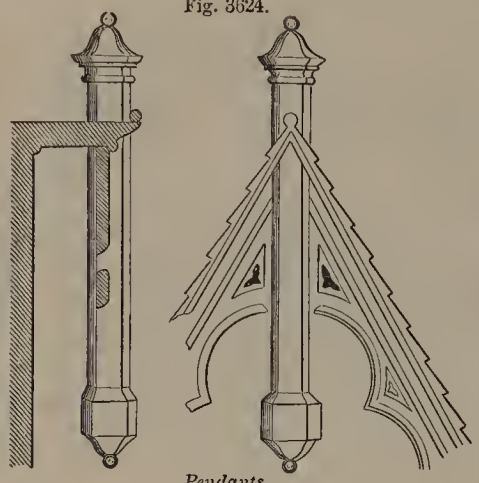
b. A hanging keystone, the lower face projecting beyond the intrados of the arch.

3. An ear-ring or bob.

4. The part of a watch by which it is suspended. Usually consisting of a guard-ring and pusher-pin.

5. A suspended chandelier.

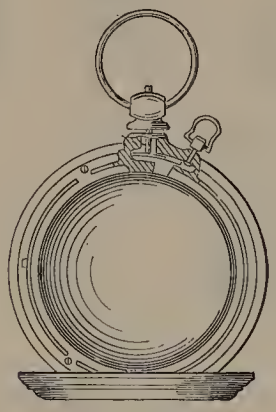
Fig. 3624.



Pendants.

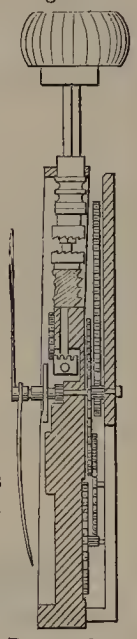
Pen'dant-wind'ing Watch. (*Horology.*) One whose spring is wound up by the rotation of the

Fig. 3625.



Watch-Pendant.

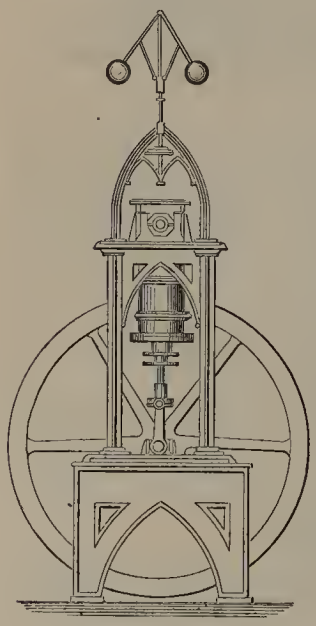
Fig. 3626.



Pendant-Winding Watch.

pendant brought into gear with wheels connecting to the spring-arbor. In the example, the spring is wound and the hands set through the stem of the pendant; a single inflexible rod operates each mechanism. For setting, the stem is partially retracted, and the watch is wound by rotating the stem at its normal projection. See also STEM-WINDING WATCH.

Fig. 3327.



Pendulous-Cylinder Steam-Engine.

Pen-dent'ive. (*Architecture.*) *a.* The filling in of the spandrels between the arches of a vault.

b. Also between the arches under a dome.

c. The portion of a groined ceiling supported and bounded by the apex of the longitudinal and transverse vaults. In Gothic ceilings of this kind the ribs of the vaults descend from the apex to the impost of each pendentive, where they become united.

Pen'du-lous-cyl'in-der Steam-en'gine. A form of oscillating-cylinder steam-engine in which the cylinder is suspended so as to oscillate below its trunnions, as seen in the illustration. The valve may be a disk-valve in the trunnion or a slide-valve on the side.

Pen'du-lum. *a.* A heavy body so suspended as to vibrate about a fixed point by the action of gravity.

Pendulums in chronometry are known by structure or function; as, —

Compensation pendulum, having isochronous means within itself for adjustment, compensating the effects of heat and cold.

Conical pendulum, having a circular path, the rod of suspension describing a cone.

Cycloidal pendulum, vibrating in the arc of a cycloid instead of a circular arc.

Gridiron pendulum, having parallel bars of brass and steel, whose diverse expansion under heat is made to preserve uniformity of the center of oscillation of the bob.

The *mercurial* pendulum, having for a bob a vessel of mercury, whose upward expansion by heat so compensates the lengthening of the rod that the center of oscillation remains the same.

The *seconds* pendulum, vibrating 3,600 times in an hour.

b. A wheel oscillating on an axis, known as a *verge*, and determining by its isochronal pulsations the movement of the train.

c. Besides these are devices not chronometric, as the *hygrometric pendulum*, *ballistic pendulum*, etc.

Previous to the application of the pendulum, a fly-wheel was used, the vanes meeting the resistance of the air, forming a limit to the speed, as in the musical boxes of the present day.

Such was probably the regulator in the clocks of the Saracens, which were moved by weights as early as the eleventh century; the clock which struck the hours, referred to by Dante (1265–1321); the clock in the old Palace Yard, London, put up about 1288 and remaining till the time of Elizabeth; the clock made by William of Wallingford in the reign of Richard II. (1377–85).

Ebn Juuis, of the University of Cordova, invented the time-measuring pendulum, and his friend and fellow-philosopher, Gerbert, invented the escapement, as it is believed. Gerbert became, successively, schoolmaster at Rheims (where he had a clock), Archbishop of Ravenna, and Pope Sylvester II. He died by poison in 1002. So did his patron, Otho III., about the same time.

An oscillating arm was substituted for the fly, probably in the fourteenth century.

The clock of Henry de Wyck, erected in 1364, for Charles V. of France, was regulated by an alternating balance (*a*, Fig 3628) which was formed by suspending two heavy weights from a horizontal bar fixed at right angles to an upright arbor, and the movement was accelerated or retarded by diminishing or increasing the distance of the weights from the arbor.

The clocks erected at Strasburg, 1370, Courtray, 1370, and Spire, 1395, were probably of this character, as were also the astronomical clocks of Tycho Brahe and other less celebrated astronomers of his period.

b shows the Harris pendulum as contrived by him in the clock put up in the turret of the Church of St. Paul, Covent Garden, London, in 1641. It will be seen that it may have occurred as a modification of the De Wyck vibrating arm, one of the weights being taken off and the arm hung vertically.

Galileo, about 1581, observed the swinging of a suspended lamp and the regularity of the vibrations recommended a pendulous weight as a time-measurer. He applied it as such successfully, at first employing persons to count the oscillations, but soon effected it by machinery.

Dr. Thomas Young in his lectures on Natural Philosophy and the Mechanic Arts, 1807, Vol. I. p. 19, ascribes the first com-

bination of the pendulum with wheel-work to Sanctorius, in 1612.

The *conical* or *spherical* pendulum is one which moves in a circle under the influence of gravitation, it and its suspending cord describing a cone, of which the point of suspension is the apex. The theory of such a pendulum is of a complicated nature, and the instrument, not being used in practical horology, possesses little interest to the non-scientific reader. It is, however, employed in controlling the rotating mechanism of the equatorial telescope. The theory of the ordinary pendulum, which vibrates in a vertical plane, was first clearly elucidated by Huyghens.

The simple pendulum is theoretically an imaginary gravitating point attached by a rigid rod devoid of weight to its point of suspension. As these conditions are impossible in practice, the actual pendulum is a compound pendulum, the weight and shape of the bob and rod serving as elements for determining a point, called the *center of oscillation*, within the pendulum, whose vibrations are performed in the same time as those of the whole mass would be were it concentrated at that point. This being done, the mathematical investigation of the vibrations of this point, oscillating freely under the influence of gravity, is identical with that of the imaginary simple pendulum.

The result of the investigation develops the following laws: 1. At equal distances from the earth's center the times of oscillation of two pendulums are directly proportional to the square roots of their lengths.

2. At different distances from the earth's center the times of vibration are inversely proportional to the square roots of the distances, i. e. to the force of gravitation.

3. The length of a pendulum vibrating seconds is directly proportional to the force of gravity at the place.

From the latter law the force of gravity, that is, the velocity with which a falling body is drawn toward the earth's center at any particular place, is readily deduced. Thus the length of the seconds pendulum at London being, according to Captain Kater's experiments, 3.2616 feet, a body will fall 16.1 nearly, at that place, during the first second of time.

The length of a pendulum beating seconds at the level of the sea in the latitude of London is 39.1393 inches.

Huyghens first observed the difference in the beats of the pendulum at different hights; and extended experiments to ascertain the density of the earth have been made with the pendulum by Professor Airy in the years 1826-28, in deep mines in Cornwall, and later in other places at great depths and hights.

From the first of the foregoing laws it follows that as the length of the pendulum varies in consequence of changes of temperature, the number of its oscillations in a given period, as the sidereal day, will also vary.

Various contrivances have been devised to remedy this defect by keeping the center of suspension and that of oscillation at a uniform distance apart. Such are known as *compensation* pendulums.

Huyghens, about 1656, designed mechanism whereby the small isochronous vibrations of a moving body could be *sustained* and *measured*. He may therefore be considered the inventor of the complete contrivance. This invention is regarded as the most important ever made in reference to practical astronomy. He soon found that the oscillations in circular arcs of different amplitudes are not equal, the wider requiring a rather longer time than the narrower, and that when oscillating in a cycloidal curve the pendulum was free from this defect. As a means of compelling the pendulum into this path, he placed cycloidal checks (*c*, Fig. 3628), whose effect upon the elastic pendulum-rod was such as to cause the center of oscillation of the *bob* to describe the arc of a cycloid, and to make oscillations in equal times whatever might be the extent of the arc described. Mechanical difficulties prevented this beautiful contrivance from being practically useful. See Huyghens's "Horologium Oscillatorium" and other works on horology.

It has been found that pendulums vibrating in very small arcs do not, however, sensibly vary their times of oscillation in consequence of a small proportional increase or decrease in the extent of that arc, and, accordingly, where extreme accuracy is required, the *amplitude* or extent of the oscillation on either side of a vertical line passing through the point of suspension is restricted within narrow limits, and provision is made for preventing, as far as possible, any change in the amplitude.

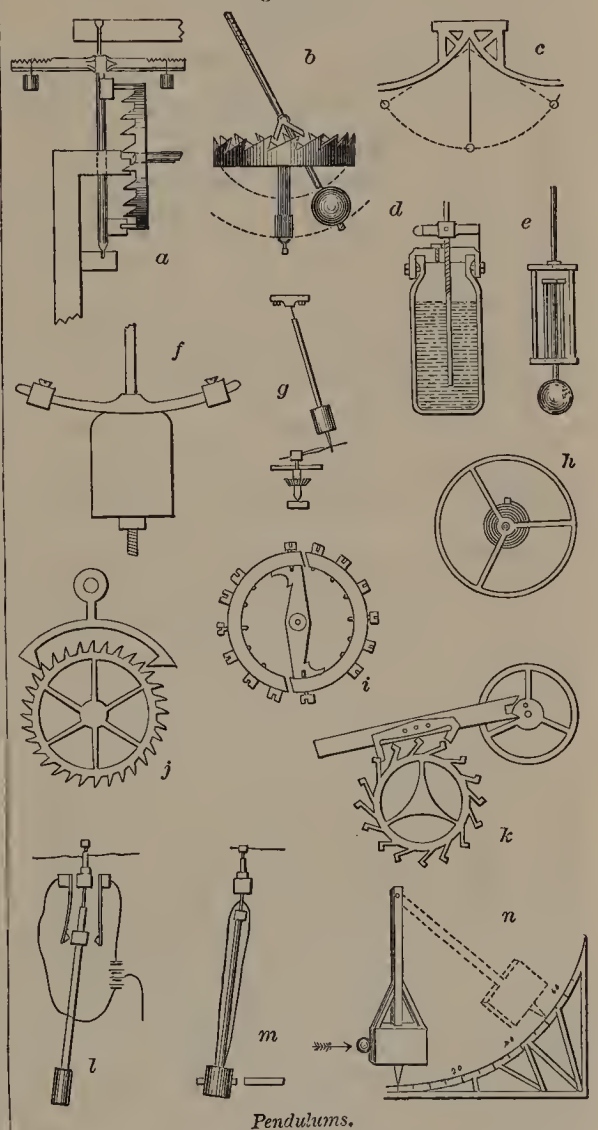
The thin, flat spring by which a clock pendulum is suspended assists in maintaining the uniformity of its oscillations.

The forms of the clock-escapements before Clement of London (1676) invented the *anchor*-escapement are not perfectly known, but were probably on the verge principle, two pallets on the axis of oscillation of the pendulum alternately escaping from the teeth of a crown-wheel propelled by the train.

Clement also devised, about the same time, the mode of suspending the pendulum from a stud by a small piece of watch-spring.

Graham, of London, invented the mercurial compensation pendulum (*d*) about 1700. In it a jar of

Fig. 3628.



Pendulums.

mercury is used for the *bob* or weight. As the pendulum-rod is expanded longitudinally by increased temperature, the expansion of the mercury in the jar carries it to a greater hight therein, and so raises its center of gravity relatively to the rod as to compensate for downward expansion of the latter.

Contraction of the rod by cold has the reverse effect, and thus the center of gravity is always kept at the same distance from the point of suspension, the effective length of the pendulum remaining the same, and the beats isochronous.

The gridiron pendulum (*c*) was invented by Harrison, and takes its name from its form, which consisted of a frame of parallel bars of steel and of brass or zinc, while the center bar of steel is fixed at top to the cross-bar connecting the middle brass bars, sliding freely through the lower bars, and bearing the pendulum-bob. The remaining bars are fastened to the cross-piece at both ends, and the uppermost cross-piece is attached to the axis of suspension. It is easy, therefore, to see that the expansion of the steel bars tends to lengthen the pendulum, while that of the brass ones tends to shorten it; and, consequently, if the two expansions exactly counteract each other, the length of the pendulum will remain unchanged. The relative lengths of the brass and steel bars are determined by the expansions of the two metals, which are found by experiments to be generally nearly as 100 to 61.

A compensation pendulum (*f*) has been contrived, in which, by means of a compound bar of metal, a certain portion of the weight of the bob is lifted when heat extends the pendulum-rod. The bent bar is a compound of brass and steel, brazed together brass downward. As brass expands more than steel with a given increment of heat, it carries the weights up with it, raising the center of gravity of the aggregate weight to compensate for the extension of the rod.

The conical pendulum (*g*) is hung by a piece of small round wire. The lower end is connected with and driven in a circle by an arm attached to a vertical, rotating spindle. The pendulum-rod describes a cone in its revolution.

A *rolling pendulum*, consisting of a cylinder oscillating in small spaces on a horizontal plane, has been suggested, but has not evinced any qualities superior to the suspended pendulum describing an arc.

In Reid's *compensation pendulum* (1818) the bob rests in a hollow cylinder of zinc, through which the rounded end of the steel pendulum is passed, the zinc itself being supported by the nut at the end of the rod. As the rod lengthens by heat, carrying the bob downward, the upward expansion of the zinc lengthens the rod and raises the bob to an equal degree.

The pendulum of the watch is an oscillating wheel termed the balance (*h*); this is impelled by the mainspring and train in one direction, and is returned by the force of the hair-spring on the arbor of the balance. It is probably the invention of Dr. Hooke. Jewels were added by Facio of Geneva about 1700. The compensation balance (*i*) was made by Harrison. (See CHRONOMETER.) The circumference is divided into two sections, the ends of which are free. The outer rim, or tire, is of brass, and the inner rim and cross-bar of steel, — these being soldered together so that one expansion counteracts the other. Cold, contracting the inner steel rim, would reduce the circumference; but, as it contracts the outer brass rim still more, an opposite effect is produced, the circumference being enlarged. The effect of expansion is checked in a similar way.

j is Dr. Hooke's anchor-escapement. *k* is the escapement known as the "lever," or "detached lever." The bar to which the pallets are attached turns upon a center-pin, so that the ends of the lever move backward and forward through small arcs, as the pallets are alternately released from the scape-wheel. One end of the lever has a little nick in it, which, as it passes backward and forward, catches a pin upon the balance, and throws it right and left. As the lever, for example, moves to the left, one of the pallets catches a tooth of the scape-wheel, and stops the train; at the same time the balance is thrown round, so that the pin passes out of the nick, and the balance swings free to the extent of the impulse, that is, it is *detached* from the lever. As it swings back under pressure of the hair-spring, the pin catches in the nick again, and, moving the lever back, unlocks the pallet, when instantly the other pallet is caught by another tooth, and the lever throws the balance the other way. The balance is therefore the pendulum of the watch, determining by its isochronal swing the rate of movement of the train.

In electric clocks the pendulum completes a circuit at each vibration. See ELECTRIC CLOCK.

Fig. 3628. *l* represents the controlling pendulum in a series of two or more clocks designed to beat isochronously. It alternately comes into contact with one of two weak springs connected with the poles of a battery having one of its middle plates connected with the earth. The bob of the controlled pendulum (*m*) is a hollow cylinder of soft iron encircled by a coil whose ends are connected through two suspending springs with a wire and the earth respectively, so that during the passage of a current the bob becomes an electro-magnet. Two magnets having their poles turned opposite ways are so fixed that the hollow bob of the pendulum always surrounds one or both of them. Thus the controlled pendulum is either checked or accelerated according as it tends to go faster or slower than the other.

2. The *ballistic pendulum* (*n*) is used for measuring the velocity of projectiles by impact. It was invented by Robins. It consists of a large mass of wood banded with iron, or of a box filled with sand-bags, and suspended by iron bars from an axis. The cannon-ball whose velocity is to be determined is fired against the solid block of this pendulum, and the hight to which it is made to oscillate by the blow is shown by an index on a wooden arc, and determines the velocity with which the mass first began to move, when its quantity of motion was equal to that with which the ball struck it.

The velocity at starting is proportional to the square root of the vertical hight ascended, whatever may be the curve; when that curve is circular, as in this instance, the velocities are as the *chords* of the arcs described; so that, if the arc be so graduated that the numbers are proportional to their distances in a straight line from 0, they will correctly express the relative velocities at starting from 0.

3. Foucault's pendulum renders visible the diurnal rotation of the earth. An account of it was presented by M. Foucault to the Academy of Sciences in Paris, September, 1852, and the apparatus was thus arranged: —

At the center of the dome of the Pantheon, a fine wire is attached from which a sphere of metal, 5 inches in diameter, is suspended so as to hang near the floor of the building. The apparatus is put in motion after the manner of a pendulum. Under and concentrical with it is placed a circular table some 20 feet in diameter, the circumference of which is divided into degrees, minutes, etc., and the divisions numbered. Now, supposing the earth to have the diurnal motion imparted to it, which explains the phenomena of day and night, the plane in which this pendulum vibrates will not be affected by this motion, but the table over which the pendulum is suspended will continually change its position by virtue of the diurnal motion, so as to make a complete revolution around its center in 24 hours. Since, then, the table thus revolves, and the pendulum which vibrates over it does not revolve, the consequence is that a line traced upon the table by a point projecting from the bottom of the ball will change its direction relatively to the table from minute to minute and from hour to hour, describing

a system of lines radiating from the center of the table. A practiced eye will actually observe that the point on the bottom of the ball does not return to the same point on the table after two successive vibrations. Thus is rendered visible the motion which the table has in common with the earth.

Foucault's experiment was soon afterward tried in the rotunda of the Capitol at Washington, which, though the dome had not then attained its present magnificent proportions, was yet sufficiently high (95 feet in the interior) to insure ample success and afford the many spectators who witnessed the slow apparent change in the plane of vibration of the pendulum relative to the fixed lines described on the pavement, convincing proof of a fact which few perhaps had previously so fully realized.

The experiment has since been repeated at many other places where there were apartments of sufficient hight to exhibit it to advantage.

Foucault afterward made an application of Bohnenberger's gyroscope, which demonstrated the same laws of motion. See GYROSCOPE.

Without tracing the demonstration all through, the result may be stated: over either pole, disturbing causes removed, such as friction, rigidity, or from the air, the pendulum would make a complete (apparent) revolution in 24 hours. The time required would increase as the plane of experiment approached the equator, varying with the sine of the latitude; at the equator no revolution would occur.

The motion is in the direction of the hands of a watch in the northern hemisphere, and in the other direction south of the equator.

4. (*Nautical.*) An instrument for measuring the *heel* or inclination of a ship, so as to assist in the laying of her guns.

5. The *hydrometric* pendulum is a *current-gage.*

Pen'du-lum-hausse. (*Ordnance.*) A species of breech-sight, having a brass bulb at the lower end which keeps it in a vertical position when the carriage is on uneven ground.

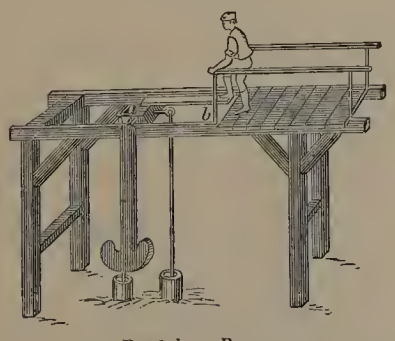
It is made of sheet-brass, and has a slit down its center in which works a slider. It is graduated to degrees and quarters, and for giving the desired elevation a notch in the slider is brought into line with the top of the front sight by lowering or raising the breech of the gun. The hausse has two side branches or trunnions, which rest in the hausse-seat. The seat is made of steel, and is permanently attached to the piece by means of screws.

Pen'du-lum-lev'el. One determining the horizontality of a surface by the verticality of a plumb bob. A mason's or bricklayer's level. See LEVEL.

The plumb or pendulum level, as a geodetic instrument, which shows the horizontal line by means of a line cutting the plummet-line perpendicularly. It consists of two legs, joined together at right angles, with a telescopic sight, and other apparatus; the whole is fixed on a stand by means of a ball and socket. Invented by Picard.

Pen'du-lum-pump. A pump in which a pendulum is employed to govern the reciprocating motion of the piston. In that illustrated, the pendulum is attached to the axis of a beam *a* connected by a transverse bar to the ends of the two piston-rods, and caused to oscillate by depressing a treadle *b*.

Fig 3629.



Pendulum-Pump.

Pen'du-lum-wheel. The balance-wheel of a watch which governs the rate of the motion. See BALANCE.

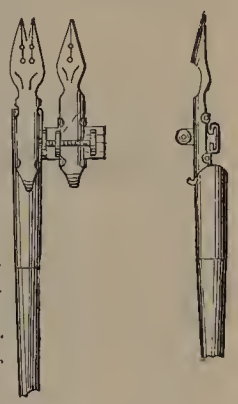
Pen'du-lum-wire. (*Horology.*) Flattened wire, by which the bob of a clock is suspended.

Pen-hold'er. A staff for a writing nib. It is usually a stick with a tubular piece having a pair of bent-in ears which form a socket into which the butt of the nib is slipped.

A more pretentious article, carried in the pocket, has a slipping piece for the pen which may be thus retracted into the handle on occasion.

The stems of pen-holders are of wood, gutta-percha, cork, vulcanite; coiled ribbons of metal or of vulcanite make holders having the pliability of the quill. Sometimes they are of a more costly material around a core of metal or wood. Some varieties may be cited.

Fig 3630.



Holland's Double Pen.

A pen-holder having an attachment to the shaft, to make a seat for the fingers and thumb, giving a better grip than the simple round barrel.

Toof (1868) has an attachment to secure oblique presentation of the pen.

Holland (1868) has a pair of pens stocked together for ruling parallel lines.

A pen-holder formed of a sheath, to place like a thimble on the end of the finger. A brush may be substituted for the pen.

A tubular sheath to prevent ink from running back on the hand when the holder is inverted.

A pen-holder having marks on which it may be poised, and with the ends so graduated in weight as to form a weighing-balance for letters of different grades of weight.

Holtzapffel's pen-holder for enfeebled hands (English, 1846) has a vertical post which is grasped by the hand and rests on the paper. The pen is held by an arm jointed to the post at an angle of 45°, and is pressed upon the paper by a feeble spring. See also PEN and PENCIL-CASE.

Pen-i-cil'lus. (*Surgical.*) A tent. *Peniculus.*

Pe'nis-syr'inge. (*Surgical.*) A small syringe from 1 to 4 ounces capacity, with a short nozzle, for introduction into the meatus urinarius. Used for injecting the urethra in venereal diseases. It is made of tin, silver, ivory, or hard rubber.

Pen'knife. A pocket-knife with a small blade or blades; so called from its former use in making quill-pens.

The blade is forged from the end of a rod of cast-steel with a light hammer upon a small anvil, and is then cut off. The joint is then finished and a temporary tang drawn out, to be driven into a handle for grinding. The nick called the *nail-hole*, in which the thumb-nail is inserted to open the blade, is stamped by a chisel while the blade is hot.

In hardening, the blades are heated in a coke or charcoal fire, and dipped in the water obliquely; pure water at 40° Fah. The blades are tempered, twelve or more at a time, on a plate of iron or copper. They are arranged close together on their backs, and lean at an angle against each other. As they come down to the temper, they are picked out with small pliers and thrown into the water, if necessary. Other blades are then thrust forward from the cooler parts of the plate to take their places. They are then finished on the glazer and polishing-wheel.

Pen-mak'er. A tool formed like a pair of pinchers for making quill-pens.

The jaws of the tool are convex and concave to receive the point of a quill which has one half cut away; and, by closing, a set of small dies form the outline of the pen, while a little blade in the middle makes the slit.

A machine on this principle was invented by Bramah, and by it six double-pointed pens were made from each quill. A very large number of pens were made in this way before the introduction of steel-pens.

Pen'nant. 1. A rope to which a purchase is hooked. See PENDANT.

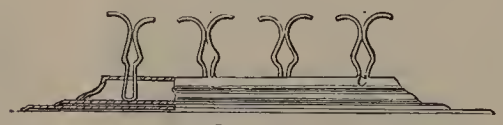
2. A long, narrow streamer borne at the mast-head by vessels of war. A *penon*.

The head is 6.24 inches to a length of 70 feet; 5.76 to 55 feet; 5.24 inches to 40 feet; 4.8 inches to 30 feet; 4.2 inches to 25 feet.

Pen'nis-tone. (*Fabric.*) A coarse woolen frieze.

Pen-rack. A piece of desk-furniture to hold an idle pen. It may consist of a row of hooks on

Fig. 3331.

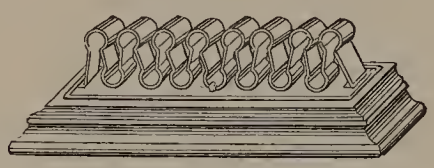


Pen-Rack.

branches rising from the base of the inkstand, or, as in the example, spring clips which embrace the penholder with sufficient strength to retain it and yet yield it to the writer.

A coil of wire slightly extended answers the same purpose.

Fig. 3632.



Spring Pen-Rack.

Pen-stock. 1. A conduit for water, usually of boards, and notably a trough of planks, which conducts the water to a water-wheel. It begins at the end of the *race*, of which it forms a continuation, and ends at the *gate*, which is lifted to discharge the water on to the wheel. A *shuttle* or *pen-trough*.

2. A sluice or flood gate restraining the waters of a mill pond or race.

3. A flood-gate used in inundating certain parts of fortified works.

Pen'ta-graph. See PANTOGRAPH.

Pent'house. 1. (*Carpentry.*) A projection over a door, entrance, window, or a flight of steps, etc., for protection from weather.

2. (*Ordnance.*) A small house, made of boards united by hooks and staples, for protecting a gun and its carriages mounted *en barbette* from the weather.

Pent-roof. (*Carpentry.*) A roof with *two* equal sloping sides. A compass-roof. A shed or lean-to roof.

Pep'per-box. A small box or caster for dredging pepper on to meat or other food.

Black-pepper is a vine with a knotty stem, which unpruned will reach the hight of 30 feet, but on Singapore Island, and probably elsewhere, is trained on poles of about 12 feet high, which are grasped by the tendrils of the vine. The branches are brittle; the leaves deep green, heart-shaped, and abundant; the blossom a cluster of small, white, almost odorless flowers. The fruit hangs in clusters of 40 or 50 grains in a bunch. At full size it is green, red at maturity, black after being picked, and then shriveled by drying on mats in the sun.

White-pepper is macerated in water until the black cuticle can be rubbed off and the grains again dried in the sun.

Pliny says that pepper was brought from India; "and what was he, gladly would I know, that ventured first to bite of pepper and use it in his meats? Who might he be that, to provoke his appetite and find himself a good stomach, could not make a shift with fasting and hunger only?"

Capsicum (red-pepper) appears to have been unknown to the ancients. It is probably a West India production.

Per-am'bu-la'tor. 1. A machine for measuring a distance traveled. It usually consists of a wheel of known circumference, say 99 inches or half a rod, with a register to record the number of revolutions.

It may be driven by hand or attached to the wheel of a carriage, as in those described by Vitruvius and those among the effects of the deceased Emperor Commodus. The latter not only measured the distance traveled, but also pointed out the hours. A *pedometer*, *odometer*, or *surveying-wheel*. See ODOMETER.

In one form of this instrument, the wheel, 8¼ feet in circumference, is journaled in the end of a stock, so that it may be lifted out of contact with the ground; on the axis of the wheel is a pinion which works another pinion on the end of a rod having at its upper part an endless screw which moves a train of gearing that gives motion to two hands on an index registering the distance to miles, furlongs, rods, and yards. The instrument is furnished with a stop, so that after measuring a certain distance it may be carried on without altering the position of the hands.

2. A child's carriage propelled from behind.

Per'bend. (*Masonry.*) A *header*-stone which passes through the whole thickness of a wall.

Per-cale'. (*Fabric.*) A cotton goods, printed or plain, and with a linen finish.

Per-ca-line'. (*Fabric.*) Fine French printed cotton goods.

Perch. 1. (*Vehicle.*) *a.* A pole connecting the fore and hind gears of a spring carriage. It has lateral strengthening-bars, called *hind-hounds*, in a wagon.

It is strengthened on the under side by the *perch-plate*.

The *strap* passes from the perch to the foot of the *kingbolt*.

b. An elevated seat for the driver.

2. A console. A bracket.

Per'co-la-tor. A filtér. The term is specifically applied to the filter of the pharmacist; and to the French coffee-pot, in which the boiling water is filtered through the ground coffee.

The coffee-percolator was invented by Benjamin Thompson, Count Rumford. It consists of an upper cylindrical vessel with a perforated bottom, in which the ground coffee is placed and covered with a perforated disk having a stem by which it may be pressed down so as to compact the coffee and allow boiling water poured thereon to percolate the mass and pass into the coffee-pot below.

In Jones's percolator the lower vessel is heated by a spirit-lamp, and the generated steam forces the water up through a pipe at the side and filters through the coffee placed in a vessel with a perforated bottom above. See COFFEE-POT.

Per-cus'sion-cap A small cylinder of copper adapted to fit on the nipple of a gun and having a flake of fulminating powder inside, which is exploded by the fall of the hammer upon the nipple, communicating fire through the latter to the charge in the gun.

Detonating powder or pellets were used in 1807, having been patented in England by Rev. Mr. Forsyth for use with artillery; but the charging of caps therewith was a later invention. The percussion principle had a hard struggle with the old flint-lock in the armies of Europe and America until long after it was universally adopted for sporting purposes.

It was not introduced into the United States service until 1842. Caps were invented in England in 1814 by Joshua Shaw. He came to the United States for the purpose of procuring a patent, but was refused as an alien. In 1822, he patented a percussion-lock; in 1828, the percussion-wafer primer. He subsequently received $17,000 from the United States government for his improvements, and died in 1860. Caps for small-arms are made of thin sheet copper, those for sporting guns, etc., usually having longitudinal striations.

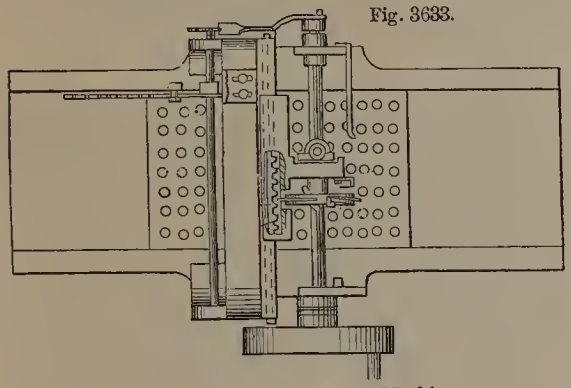
The composition used in the United States service is fulminate of mercury mixed with half its weight of niter. This renders the fulminate less explosive, and gives body to its flame; it is protected by a drop of copal varnish, which soon dries in a thin film, preventing access of decomposing agents. Tin-foil is also employed for the same purpose.

In the British service, a composition of 6 parts fulminate of mercury, 6 chlorate of potash, and 4 antimony, is used. The machines for making caps display great ingenuity. In Boughton's they are stamped from strips of copper previously cut to proper widths, and then charged with the compositiou. Wright's machine cuts the blanks from the sheet, forms, and charges them with fulminate at one continuous operation. The varnish is applied by a very simple device to a whole row of caps arranged in holes in a board. Percussion-caps of paper, fitting on the hammer, were formerly used for cannon, but have been superseded by quill-tubes and friction-primers.

Separate caps for military purpose are now mostly disused, having been superseded by the modern capped metallic cartridge, in which the fulminate is applied inside the base of the shell, forming a ring in rim-fire cartridges or a cap in the center of central-fire cartridges. With many of the latter class detachable caps are used, which are inserted from the outside in a depression in the base of the shell. See CARTRIDGE.

Per-cus'sion-cap Fill'ing-ma-chine'. The metallic bodies of percussion-caps are placed in perforations in a plate, open end upward. A plate with corresponding but smaller perforations is placed on

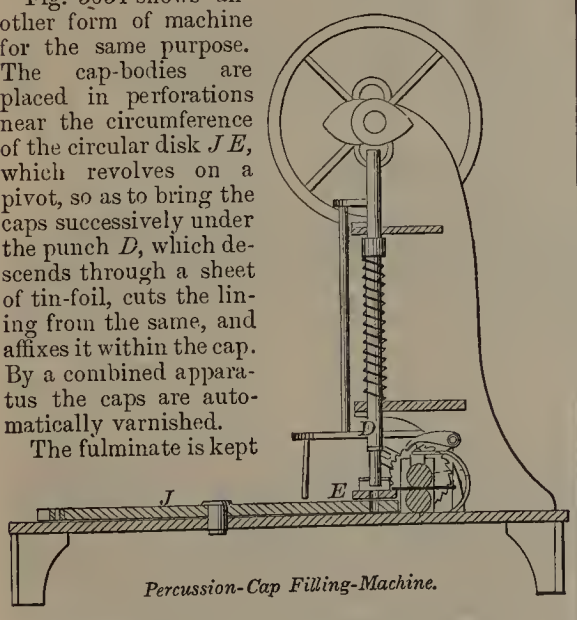
Fig. 3633.



Percussion-Cap Filling-Machine.

a flat table, and damp fulminate brushed lightly across it till the perforations are filled. This plate is then placed over the empty caps and the powder shaken down into them. The charged caps are then passed to a machine similar to Fig. 3633, in which the punch moves on a stationary guide across the plate, and, entering each hole, lines the caps in succession with the tin-foil, the plate being moved as each row is completed. A second punch may be used to apply a drop of varnish after the lining is in place.

Fig. 3634.

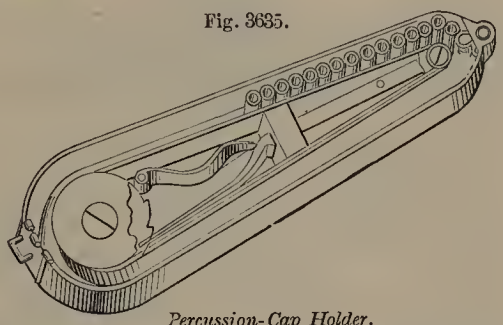


Percussion-Cap Filling-Machine.

Fig. 3634 shows another form of machine for the same purpose. The cap-bodies are placed in perforations near the circumference of the circular disk *J E*, which revolves on a pivot, so as to bring the caps successively under the punch *D*, which descends through a sheet of tin-foil, cuts the lining from the same, and affixes it within the cap. By a combined apparatus the caps are automatically varnished.

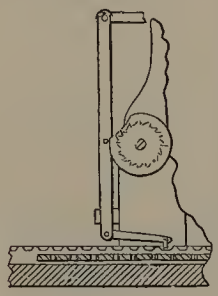
The fulminate is kept wet during the operations of filling, and not more than twelve ounces of the composition is allowed in an establishment at one time.

Fig. 3635.



Percussion-Cap Holder.

Metallic cartridge-shells are primed with fulminate and varnished in the inside in the same way as caps, but the tin-foil is generally dispensed with. The separate caps for Parker's and Maynard's, and some other central-fire cartridges are made in the same manner as gun-caps, but the shells are shallower. They are inserted in depressions in the head of the cartridge, the head of the cap on a line with the surrounding shell and forming part of the head of the cartridge.

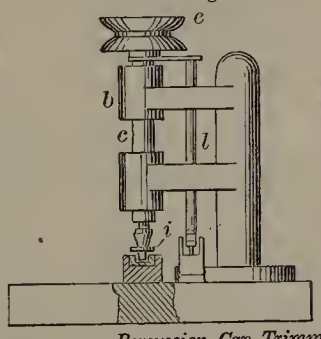


Per-cus'sion-cap Hold'er. A sportsman's device for holding caps in such way as to be readily attached to the nipple of the piece. The caps are arranged in a groove and fed toward the opening by a spring. One is always presented at the point of discharge in convenient position to be slipped over the nipple, and then withdrawn from the case by a pull. The next in series immediately assumes the place at the opening.

Per-cus'sion-cap Trim'ming-ma-chine'. For trimming the edges of cap-bodies after they have been formed by the dies.

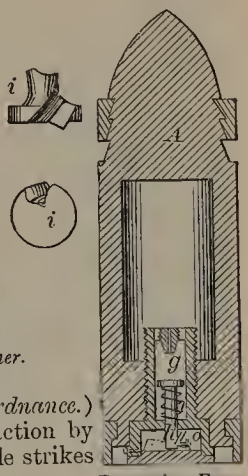
The caps are placed in perforations in a plate and passed beneath a rotating cutter-disk to trim the edge. Fig 3636 shows a machine of this character, in which *b* is a bearing for shaft *c*, which carries the cutter *i*. *e* is a pulley round which the driving-belt passes, and *l* is a gage or lever to raise and depress the cutter-shaft, so that it may operate on the caps as they are brought beneath the cutter.

Fig. 3636.



Percussion-Cap Trimmer.

Fig. 3637.



Percussion-Fuse.

Per-cus'sion-fuse. *(Ordnance.)* A fuse in a projectile set in action by concussion when the projectile strikes the object.

In the example, *A* represents a shell. A plunger *h* held by a spring *i* and detent *o*, which engages in a notch at its rear end, is released by withdrawal of the detent occasioned by the shock of impact, and strikes a nipple *g* on which is a percussion-cap.

Per-cus'sion-grind'er. A machine for crushing quartz or other hard material by a combined rubbing and pounding process.

Per-cus'sion-lock. (*Fire-arm.*) One in which the *cock* or hammer strikes a fulminate to explode the charge.

The percussion principle was first applied to fire-arms by the Rev. Mr. Forsyth of Belhelvie, England, in 1803.

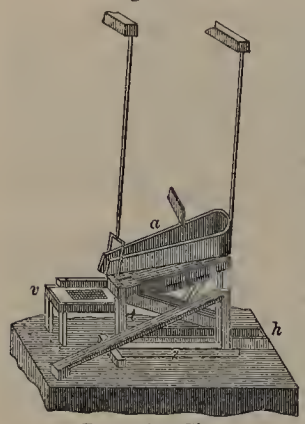
The interior mechanism may be the same as that formerly used in the flint-lock, the shape of the hammer being altered to allow it a greater sweep, and the *battery* and *pan* replaced by a *nipple* or *cone*.

Per-cus'sion-pow'der. An explosive ignited by percussion. See FULMINATE.

Per-cus'sion-sieve. (*Metallurgy.*) An apparatus (*crible à secousses*) for sorting ores, principally those of lead, but closely allied to the tin and copper apparatus.

It consists of two inclined sieves, the upper one of which discharges on to the second and lower one. The upper sieve *a* is fed by the shovelful, and receives a vertical agitation by means of a lifting lever operated by a wiper-wheel on the machine-shaft. Water is also conveyed into the sieve, and the larger refuse or chunks of ore which are too large to fall through the grating are received upon the table *v*, while the other matters fall on to the second inclined and finer sieve *t*, which is similarly agitated and provided with a water-sluice. The fragments which do not pass through the meshes are collected in the box *h*, while the smallest portions fall into the cistern *z*.

Fig. 3638.



Percussion-Sieve.

This sorting is not like the operations on tin, such as *jigging*, *framing*, *racking*, *tying*, *trunking*, *buddling*, *tossing*, etc., in all of which the attempt is made to sort the comminuted ore by *gravity*. In the *percussion-sieve* the sorting is entirely by *size*. See the above processes for gravity arrangement. See also CONCENTRATOR; ROCKER.

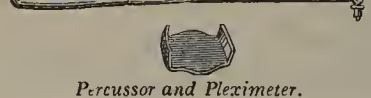
Many of the miners' operations in collecting gold are by gravity. See GOLD-MINING.

Per-cus'sion-stop. (*Music.*) A piano-forte stop to the organ, which renders the touch like the former.

Per-cus'sion-ta'ble. (*Metallurgy.*) A form of ore-separating apparatus consisting of a slightly sloping table on which stamped ore or metalliferous sand is placed to be sorted by gravity. A stream of water is directed over the ore, and the table is subjected to the concussion at intervals.

The French apparatus (*table à secousses*) is like the rack used in the tin-works of Cornwall. The comminuted ore is brought upon the swinging table by a thin sheet of water, and, being spread in a state of mechanical suspension in the liquid, is caused to arrange itself to some extent by gravity, as the heavier grades will sink the sooner while the lighter pass to a greater distance down the inclined table. The latter is suspended in such manner as to receive a double motion, horizontally and vertically, the latter being accompanied by a jar, as the table drops upon two wooden stops.

Fig. 3639.



Percussor and Pleximeter.

Per-cus'sor. A hammer employed in auscultation, in connection with a plate placed on the chest and called a *pleximeter*. For other auscultation instruments see STETHOSCOPE; SPIROMETER, etc.

Pe'rer. (*Ordnance.*) An old form of ship's gun, for throwing stone-shot.

Per'fect-ing. (*Printing.*) Printing the second side of a sheet.

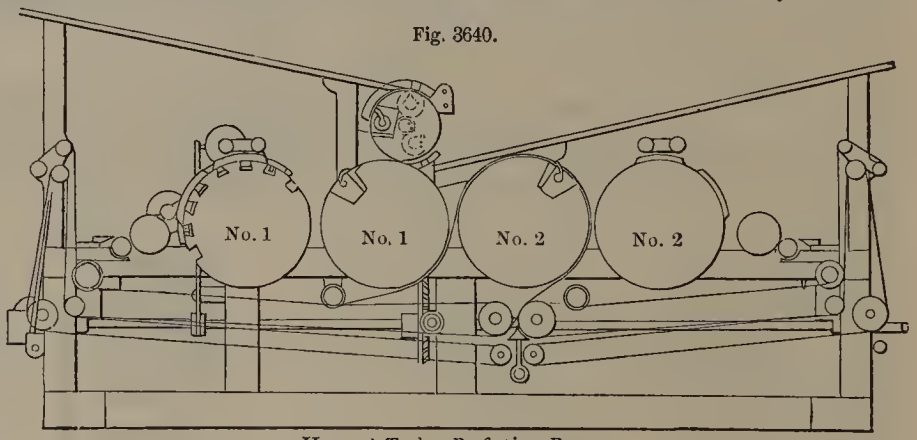
Per'fect-ing-press. (*Printing.*) One in which the paper is printed on both sides during one passage through the machine. In Hoe's rotary-cylinder perfecting-press, two impression-cylinders and two form-cylinders are placed side by side in a horizontal frame, the impression-cylinders occupying the center, with the form-cylinders at each end. The two forms are attached to their cylinders, and inked as in the usual type-revolving press, the fountains and distributing cylinders being placed at the ends of the press. The sheets are supplied by feeders in the usual manner; they are delivered by a feeding-cylinder to the first impression-cylinder, whence they go to the second impression-cylinder, and are thence conducted right and left alternately to a sheet-flier at each end. See also PRINTING-PRESS; WEB-PRESS.

In the flat-bed perfecting-press the bed has a reciprocating motion, the paper being transferred automatically from the first impression-cylinder to the second, and then conducted by tapes to the self-acting sheet-flier. The second cylinder is provided with reels holding a large roll of facing blanket, which, as it becomes soiled by the set-off from the first side of the sheet, is rolled up and a fresh portion brought into use.

The machine may be arranged to have an additional feed-board, from which a set-off sheet may be fed to the second impression-cylinder. the two sheets being thrown out together on the fly-board and separated by hand; or, a sheet-flier may be added for the set-off sheet, which is then separated automatically from the printed sheet and flown on a separate board.

In the press shown in Fig. 3640, the sheets, as they come from the printing mechanism, are directed alternately on opposite sides, so as to be delivered in two piles, either by two separate fly-frames or a double-acting fly-frame. The plates are clamped directly to the surface of the type-cylinder, so as to dispense with the use of blocks and iron frames commonly used.

Fig. 3640.



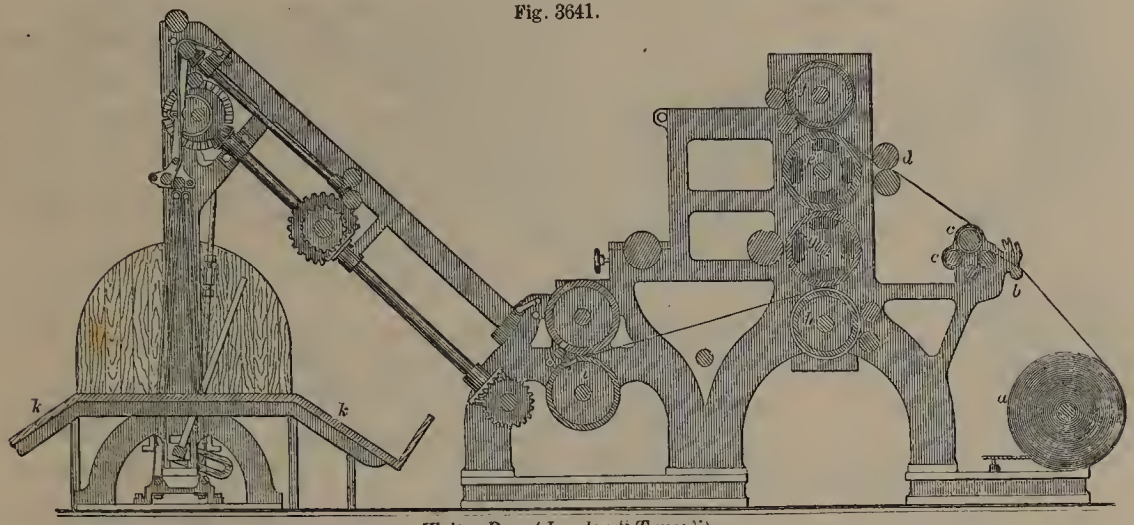
Hoe and Tucker Perfecting-Press.

A late style of perfecting-press uses a double form which engages with a cylinder both in its forward and backward movement, the cylinder performing only a partial revolution and returning with the form. An inking-apparatus on each side of the cylinder inks the form as it passes, and a reversing apparatus on one side takes the sheet after the first printing, reverses it, and returns it to the grippers The back stroke of the press completes the printing, and the sheet is then cut in two

The Walter's English press, which prints the London and the New York "Times," is shown in Fig. 3641. A roll of paper *a*, three miles long, reels off over the pulley *b*, which serves to keep it taut, and is damped in passing the cylinders *c c*. The web then passes over the cylinder *d* to the first type-cylinder *e*, between which and the blanket-cylinder *f* it receives its first impression. Following the direction of the type-cylinder it passes between two blotting-cylinders, and is then delivered to the second printing-cylinder *g*, receiving the impression at *h*. It is then cut by a knife on the cylinder *i*. The sheets are finally piled on the paper-boards *k k*. The speed of the Walter press is said to be 11,000 printed sheets, or 22,000 impressions, per hour.

The Bullock press, so named from the inventor, the late William Bullock of Philadelphia, carries the forms upon two

Fig. 3641.



Walter Press (London "Times").

cylinders, requires no attendants to feed it, and delivers the sheets printed on both sides.

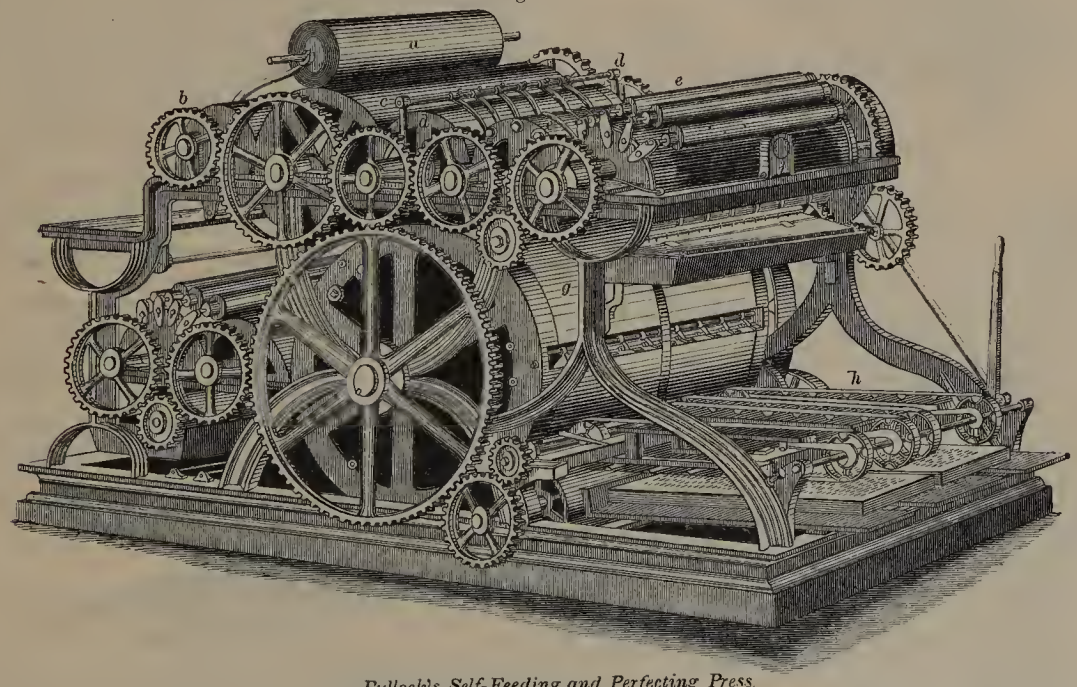
The paper in the form of an endless roll is moistened by passing through a shower of fine spray. A single roll will contain enough for several thousand sheets, and the printing operation, including the cutting of the paper into proper lengths, proceeds uninterruptedly until the roll is exhausted.

The roll of paper having been mounted in its place, the machinery is started, unwinds the paper, cuts off the required size, prints it on both sides at one operation, counts the number of sheets, and deposits them on the delivery-board at the rate of eight thousand to fourteen thousand per hour; or, counting both sides, at the rate of sixteen thousand to twenty-eight thousand impressions. The labor is only that of placing the rolls on the press and removing the printed paper.

The press is shown in perspective in Fig. 3642. The roll of paper *a* on top is cut into sheets by a knife on roller *b* acting against the cylinder *c*. The sheets are seized by grippers, carried between the impression-cylinder *g* and the *form* *e*, receiving the first impression. The printed sheet then follows the large cylinder *g* to the second *form*, receiving its second impression from this *form* acting against the large drum *g*. From the large cylinder the sheets are automatically delivered to the receiving-board. *i* is a counting device or arithmometer. The inking-rollers are shown above the inking-cylinders, beneath which are the ink-troughs. The starting-lever is shown on the right.

Fig. 3643 shows parts of the Bullock press detached, for a better understanding of their operation. *A* is a section midwise of the principal working parts. *a* is the roll of paper which is cut off in sheets by the knife on cylinder *b*, which strikes through the web of paper into slots in the cylinder *c*. As soon as the sheet is cut off it is grasped by grippers on *c*, passed to impression-cylinder *d*, and around that, between it and type-cylinder *e*, where the first side is printed. It is then seized by

Fig. 3642.



Bullock's Self-Feeding and Perfecting Press.

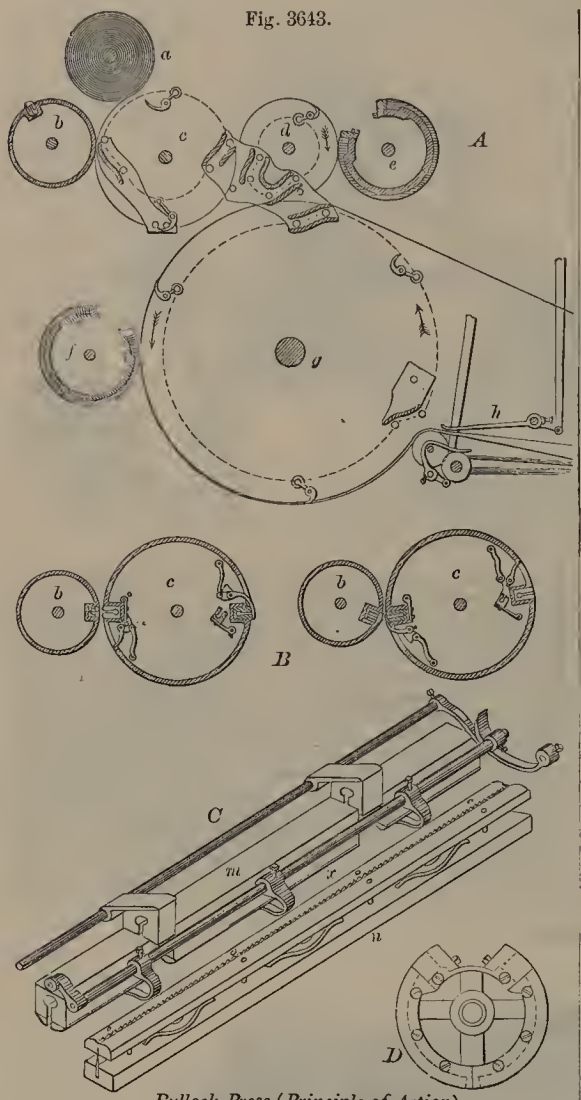
grippers on the large cylinder *g*, and carried between that and the second type-cylinder *f* to print the other side. The sheets are taken from the large cylinder by endless belts which pass over pulleys, and are piled by the action of the flier *h*.

The large cylinder *g* is covered with a blotting-pad to prevent offset when the face of the freshly printed sheet is carried on to it from cylinder *d*. The inking-rollers, not shown in this view, are kept constantly in contact with the type or plates on cylinders *e f*. The grippers are so arranged that the delivery of a sheet from one set to another is certain and uniform.

B shows the cutting and receiving cylinders, with the grippers on the latter in their positions before and after the sheet is cut from the web. *C* shows the knife *x* and carrier *n*, and the slotted block *m*, into which the cut is made. The carrier *n* is a segment of cylinder *b*, and *m* is a similar portion of *c*.

D is an end view of the printing-cylinders *e f*. The plates from which the printing is done are of extraordinary thickness, and are cast to fit the cylinders in circular molds. The molds are made in plastic material spread on a steel plate which is pressed flat, but which assumes a circular shape when released,

Fig. 3643.



Bullock Press (Principle of Action).

curving the mold with it Kellberg's arrangement of the Bullock press cuts the sheets after printing.

The Victory press, shown under PRINTING-PRESS, is also a *web-press*, and damps, prints, cuts, folds, and pastes at the back a 24-page paper like the "Christian Union" of New York, at the rate of 7,000 per hour.

Per'fo-rat'ed File. A file invented by Hiram Powers, having openings through which the abraded material is allowed to escape. It is especially intended for sculptors' use.

Per'fo-rat'ed Saw. One having a series of apertures behind each gum of the teeth, as originally made. These serve to prevent fractures at the bases of the teeth, and lessen the amount of filing required, becoming themselves the gums after each refiling. See SAW.

Per'fo-rat'ing-ma-chine'. 1. (*Mining.*) The rock-drilling machine used in tunneling. See TUNNEL; DIAMOND-DRILL, etc.

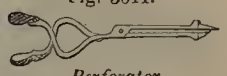
The machine used at the Mt. Cenis Tunnel was worked by air compressed by water-power. The air is compressed to 90 pounds per square inch, and conveyed in flexible pipes to the workings. The machines are on tramways, and upon them are mounted jumpers, which are reciprocated by the action of compressed air. The force of the blow is estimated at 180 pounds, and the rate is three strokes per second. The depth in the average rock is about 0 6 inches per minute. The drill is rotated one eighth of a revolution at each retraction. A jet of water clears the débris from the hole.

2. (*Paper.*) The machine which makes the rows of perforations on sheets of postage-stamps has a couple of cylinders revolving together. The upper one is provided with punches, and the lower one has counterpart holes. As the sheet is passed between them, the holes are made and the little disks of paper fall into the hollow lower roller. The machine will perforate 250 sheets per hour, and the punches and holes are adjustable for stamps of different sizes.

3. (*Telegraphy.*) A machine for making holes in paper for messages to be sent by the automatic method.

Per'fo-ra'tor, Ob-stet'ric. (*Surgical.*) An instrument for perforating the skull of the fetus in utero, as a means of prehension to draw it past the pelvic cavity. The operation is known as *cephalotomia.*

Fig. 3644.



Perforator.

Per'fume. From the Middle Ages up to the last century musk, civet, ambergris, and lavender sum up the best-known and most popular perfumes. Six flowers form the base of most European flower-scents: orange-flower, rose, jasmine, violet, acacia, and tuberose; heliotrope is imitated by vanilla dashed with almonds. To these are added geranium, lavender, rosemary, thyme, and other aromatic herbs; also the peel of bitter oranges, of which the fruit goes to make curaçoa; the peel of citrons and bergamots, musk, sandal-wood, ambergris, and gum benjamin; the leaves of the patchouli (*Pogostemon patchouli*, one of the Labiatæ), from India; wintergreen (*Gualtheria procumbens*), from the United States; various of the Andropagons, from Ceylon; ihlang-ihlang (*Unona odoratissima*, one of the Anonaceæ), from the Philippine Islands; vanda (*Acrides suaveolens*, an orchid), chiefly from Java, but from other places too in the Indian Archipelago; frangipanni (*Plumeria alba*, one of the Apocynaceæ), from both the East and West Indies. The French are the greatest producers of perfumes; there are two notable exceptions, *attar gul*, or attar of roses, and eau-de-cologne.

See Morfit's "Perfumery," Philadelphia, 1853.

Per'get-ing. See PARGETING.

Per'i-a'gua. A canoe formed by hollowing out a single log or by joining two logs correspondingly hollowed out. A *dug-out.*

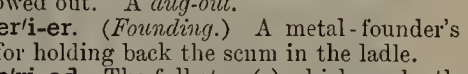
Per'i-er. (*Founding.*) A metal-founder's iron rod for holding back the scum in the ladle.

Pe'ri-od. The full stop (.) which marks the end of a sentence in punctuating, or indicates an abbreviation, as Mr., Jan., B. C., etc.

Pe-ri-od'o-scope. (*Surgical.*) An instrument for determining the date of menstruation, labor, etc., and for other calculations.

Per'i-os'te-um-el'e-va-tor. (*Surgical.*) A device for loosening and raising the periosteum out of the way of an instrument in making exsections, etc.

Fig. 3645.



Periosteum-Elevator.

Per'i-scop'ic Lens. (*Optics.*) Dr. Wollaston's *periscopic* lens for microscopes had two plano-convex lenses ground to the same radius, and between their plane surfaces a thin plate of metal with a circular aperture. The aperture had a diameter equal to one fifth the focal length.

It was proposed to fill up the central aperture with a cement of the same refractive power as the lens.

Another mode, proposed by Coddington, was to make a deep equatorial groove around a sphere of glass in the plane of a great circle perpendicular to the axis of vision; the groove to be filled with opaque matter.

The *periscopic* lens for spectacles is concavo-convex, the ratio of the radii of the respective surfaces constituting it a magnifying or diminishing lens, as the case may require.

The object is to give the lens a curved surface approximating that of the cornea, for the purpose of increasing the distinctness of objects when viewed obliquely.

Per'i-style. (*Architecture.*) A row of columns surrounding the interior of a place.

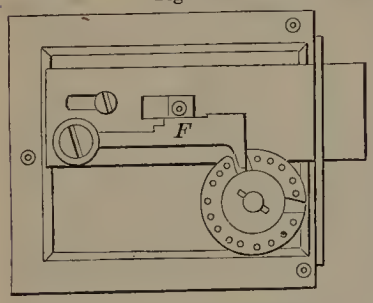
Per'ma-nent Way. (*Railway Engineering.*) The finished road-bed and track, including bridges, viaducts, crossings, and switches. The term is used in contradistinction to a temporary way, such as is made in construction, in removing the soil of *cuttings* and in making *fillings*.

Per-mu-ta'tion-lock. (*Locksmithing.*) A lock in which the moving parts are capable of transposition, so that, being arranged in any concerted order, it becomes necessary before shooting the bolt to arrange the tumblers. The LETTER-LOCK (which see) appears to have been the earliest of this class; and locks on the same principle, but of more complicated mechanism, still form a favorite subject of invention.

The permutation principle was introduced into tumbler-locks by Dr. Andrews of New Jersey, about 1841. The tumblers are capable of variable adjustment, and the key has a series of small shiftable steel rings of such radii as to suit the variable tumblers.

To this succeeded the Hobbs lock, invented by Newell of New York, which is provided with a series of secondary tumblers separated from the main tumblers by a wall; the secondary tumblers have notches corresponding to teeth on a series of intermediate tumblers, which teeth correspond to the hights of the main tumblers; in shooting or retracting the bolt the intermediate tumblers are engaged with both the primary and secondary tumblers, lifting the latter to the hight determined by the variable arrangement of the movable key-bits, but when the bolt is shot they become detached, and the former, on withdrawal of the key, fall, so that their acting surfaces are all on the same level, affording no indication of the hight to which they must be lifted in order to withdraw the bolt; the wall prevents all access to the secondary tumblers for this purpose.

Fig. 3646.



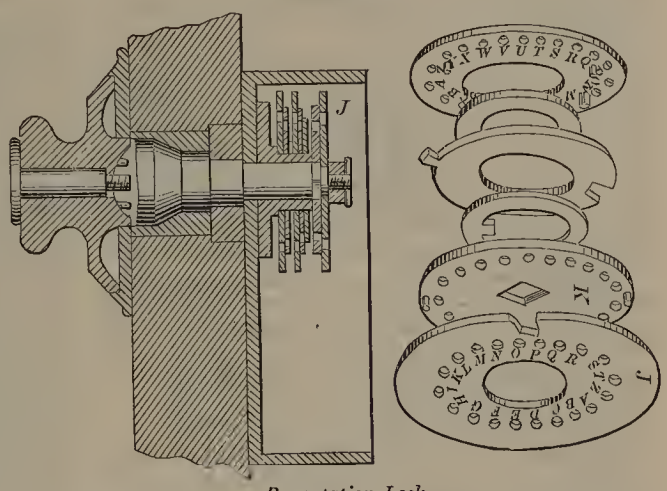
Permutation-Lock.

In Fig. 3646, the movement of the bolt is effected by the direct action of a series of rotating tumblers. A bar *F* pivoted at one end to the bolt carries at the other end a projecting tooth, which, when the tumblers are arranged in a certain position, falls into the notch or gate. By turning the spindle, the toothed bar is drawn upon by the tumblers, and the bolt will thus be projected outward, and by turning still farther, the tooth will ride up out of the gate and rest with its point upon the periphery of the series, in doing which a notch on the upper surface of the toothed bar will embrace a permanent stub projecting from the lock-plate, and thus render the bolt immovable until the tumblers shall have been so arranged as to permit the tooth to again fall into the gate.

In Fig. 3647, a dog connected with the bolt engages notches in the tumblers *J*; between these are secondary wheels *K* communicating motion from one tumbler to another, and adjustable thereon, so that the tumblers may be set to any desired combination.

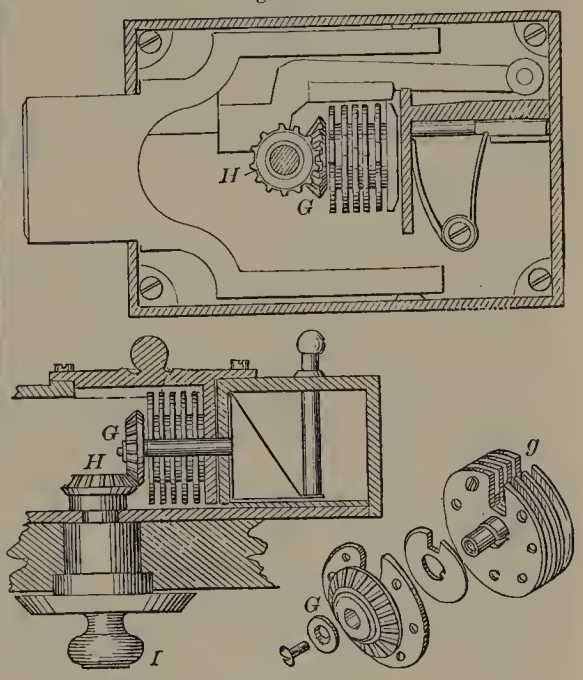
In Fig. 3648, the arbor of the tumblers is at right angles with the knob-spindle *I*, and the latter carries a miter-wheel *H* engaging a similar wheel on the outer tumbler-wheel. The combination is discovered by the introduction of a pin into the back-plate of the lock when the door is open. The pin impinges upon the inclined head of a pintle, and forces it through the slots *g* of the tumbler-wheels *G* as they are brought into line by turning the knob. The combination is shown by the position of the index-finger when the pin enters each slot.

Fig. 3647.



Permutation-Lock.

Fig. 3648.



Bank Lock.

In one patented lock of this class a vibrating dog is pushed away once in each rotation of the spindle and frees the fence; if then the notches of the tumblers be in line, the fence falls into them and the bolt may be thrown by the spindle. In another, the backward movement of the bolt on shutting the door throws the tumblers out of adjustment by means of a spring-arm.

In a third, a dog pivoted to the case holds the bolt unless the tumblers are in such adjustment as to let the fence fall into corresponding notches in the tumblers, when the head of the dog gravitates and falls from opposing contact with the bolt.

A fourth has a dog on the armature of a magnet held out of contact with a series of permutation-wheels until the spindle which moves the bolt is rotated a certain distance; the armature is then freed and attracted toward the magnet, causing the dog to enter notches in the wheels.

In a modification of the above, the magnet is pivoted and oscillates between an upper and a lower position.

Permutation-locks are constructed with or without keyholes; in the former case the tumblers are set by the key-bits; in the latter, they are brought into adjustment by rotating the knob-spindle back and forth, according to a preconcerted series.

Table of Permutations whereby any Questions of Permutation from 1 *may be solved by Inspection, the Number of Terms not exceeding* 20.

1	1	11	39916800
2	2	12	479001600
3	6	13	6227020800
4	24	14	87178291200
5	120	15	1307674368000
6	720	16	20922789888000
7	5040	17	355687428096000
8	40320	18	6402373705728000
9	362880	19	121645100408832000
10	3628800	20	2432902008176640000

See LOCK; LETTER-LOCK; WHEEL-LOCK. See list under LOCK.

Per-pend'er. (*Masonry.*) A stone going through from side to side of a wall and acting as a binder, called also perpend-stone, through-stone, through-binder. A course of such is called a perpend-course, and a wall in which all the stones run through from side to side a perpend-wall.

Per'pen-dic'u-lar Lift. See CANAL-LIFT.

Per'pent. A bond-stone; a large stone reaching through a wall so that it appears on both sides of it.

Per-pet'u-al Mo'tion. An *ignis fatuus* which has led astray some persons of limited scientific knowledge in all ages and regions. As the knowledge of scientific truth advances, we arrive at some axioms, and we now know that motion involves an expenditure of force, and that even a balance-beam poised by steel edges on agate plates and started pulsating, meets with the resistance of the air and generates some friction between the contacting surfaces, and must come to a stop. The modern demonstration of the convertibility of the various dynamic forces has made the matter more clear and explainable.

It is impossible to make a machine which shall move without a motor, or which shall maintain the motion originally imparted to it unimpaired for an indefinite length of time, without receiving an accession of power.

Perpetual motion induced by natural fluctuations, such as the rise and fall of the tides, of the waves, the flow of a river, the pressure of wind, variations in the weight of the atmosphere, expansion and contraction by heat and cold, do not come within the conditions of the problem of the perpetual motion, the mechanical problem which has annoyed so many. These are subject to recurrent fluctuations and changes which may give a more or less constant motion to objects, and have been made use of in all ages. For an interesting and comprehensive dissertation on this subject, see "Perpetuum Mobile," Dircks, London, 1861.

The Marquis of Worcester, in his "Century of Inventions," refers to a number of contrivances which appear through the fog of the descriptions to be attempts at perpetual motion. The old cavalier was rather curious than profound. He was a genuine gentleman, and true to a false master in victory and in defeat.

The "Siddhânta Çiromani," a Sanscrit text-book on astronomy, gives an account of a wheel having on its outer edge a number of holes of equal size and at equal distances from one another, but upon a zigzag line; these holes are filled half full of mercury, and stopped at the orifice; and it was claimed that the wheel will then, if supported by an axis upon a couple of props, *revolve of itself.*

Bishop Wilkins (b. 1614, d. 1672), in his "Mathematical Magic," tells of perpetual motion produced by "chymical attractions" caused by grinding mercury and some other substances together; in distilling and redistilling the mass until small atoms are produced, which, being placed in a glass globe, serve to keep it perpetually moving. The worthy bishop does not, however, repose implicit confidence in the efficacy of this means to produce the desired result.

According to Thomas Tymme, a certain Cornelius Dreble devised a machine representing the revolutions of the sun and moon, exhibited before King James I., which was actuated by a fiery spirit contained within the axle of the wheel. These things were certainly quite as adequate to cause movement without power as any of the mechanical contrivances afterward devised for the purpose. Among the first of these which we meet is one depending on magnetic attraction. A ball rolled down an inclined magnet, dropped through a hole at its lower end, was then to be attracted by the other pole so as to ascend along a curved surface, pass through another hole in the upper part of the magnet, again roll down, and so on *ad infinitum.* Just one half the result was verified; the ball rolled down in strict accordance with the programme, but refused to ascend without coercion.

Next appears the time-honored wheel rotated by plummets or pivoted weight-levers so arranged that those on the descending side shall always preponderate. This form of perpetual motion frequently recurs at the present day.

Nearly allied to this is the wheel having grooved or hollow spokes, along which a series of balls move alternately inwardly and outwardly between the axis and the circumference, so that the greater weight shall always be on the side which is descending. Though it has been mathematically demonstrated hundreds of times, so as to appear almost in the light of a self-evident proposition, that even were there no friction between the acting surfaces, the resultants obtained by multiplying the weights by their distances from a vertical plane passing through the axis of the wheel must always be equal, and that the two sides must, therefore, be in equilibrio, persons are found who are willing to spend time and money in the attempt to construct motors, maintainers, or increasers of power.

In another old form (1685 A. D.), the arms or spokes of the wheel are tubular and carry bellows containing quicksilver at each end; the idea being that when the wheel was set in motion the quicksilver would flow from each bellows as it rose above the horizontal line passing through the axis of the wheel, pass through the tube to the bellows opposite, and accelerate its downward movement.

The apparatus of Dr. Conradus Schiviers, D. D., 1790, consisted of a wheel with compartments similar to those of a water-wheel, and an endless chain passing over pulleys; a number of balls were placed in a trough at the upper part of the wheel, whence they ran down an inclined plane one by one into each compartment of the wheel, causing that side to descend; as each ball arrived at the lowest point of the wheel, it was to be discharged, scooped up by one of the buckets on the endless chain, which it was supposed would raise it to the upper trough to go through the same round. Thus the wheel would move the chain, and the chain would reciprocally move the wheel. The principle is the same as that of a man lifting himself over a fence by taking hold of the straps of his boots.

In the same year, John Haywood invented a perpetual-motion machine strongly suggestive of some "mechanical movements" which have appeared within the past few years. It embraced a wheel with a cranked axle, to the end of which several rods were connected, passing from side to side of the main wheel, and having at their ends small wheels which rotated around the inner rim of the larger wheel; by this arrangement, the preponderance, according to Haywood, would always be on that side toward which the wheel was turning, the points at which the rods were supported by the crank arm continually shifting so as to constitute levers whose longer arms would always be on that side in every position of the main wheel. This, like the preceding, involves the absurdity of two parts reciprocally maintaining the motion of each other, without the aid of extraneous force.

Count de Thiville proposed to use a tube closed at one end, which, being suddenly immersed in water at its open end, the fluctuations produced thereby were to be utilized as a perpetual motor.

Hydraulic devices of this kind are numerous. Prominent among these is the application of a water-wheel to turn an Archimedean screw, which in turn raises the water to supply the wheel. This, also, is a chronic and persistent fallacy which, under various forms, continually reappears.

Several attempted applications of the pump in combination with a water-wheel are also found. These are all based upon the assumption that the force of the water descending in the buckets of the wheel may be made to reciprocate the pump piston, raising the water by which the wheel is turned.

In one, a siphon in an upper reservoir supplied by the pump carries the water to a series of wheels, one above the other; the water escaping from the buckets of the upper wheel falls into those of the one beneath, and so on; a supposed gain of power being effected by this means, while the siphon provides for a continuous flow.

In another device of this kind, power is supposed to be gained by a pulley on the axis of the wheel driving a smaller pulley which actuates the pump machinery, reducing the friction in the proportion of their acting surfaces. This is based upon the theory of the man who purchased two stoves which were claimed to consume but half the usual amount of fuel, that if one saved half two would save it all.

One inventor proposes to use mercury inclosed in an air-tight vessel; the mercury is partly drawn off into a reservoir below, through an aperture producing a vacuum above that which remains; this causes the mercury from the reservoir below to rise in an exhausted tube, passing upward into the vessel from which it was originally derived, and this movement is to be continuous.

Another employs water under pressure, which straightens flexible tubes affixed to the periphery of a wheel, causing its rotation; on passing a certain point, these tubes are caused to discharge, resuming their flexible condition and allowing them

to freely turn with the wheel until each arrives at the proper point to exert a propelling action.

Multiplying levers have also been employed for increasing the rotary movement originally imparted to a wheel, the short arm of one being applied to the longer arm of the next, and so on. This arrangement, if it worked in practice, would render the boast of Archimedes, that had he a place for his lever he could move the world, a mere bagatelle. A power of one pound applied in this way at one end of the series might, if the theory of perpetual-motion inventors be correct, be developed into thousands of tons at the other; and, as this would increase at each revolution of the wheel, the consequences might be fearful, so that we may consider it fortunate that in this class of machines some little obstacle which the inventor can usually account for, but never succeeds in entirely overcoming, prevents their working at all.

Many others might be enumerated besides those already mentioned, but we must be content with a few more, probably the most absurd of which is the perpetual-motion railroad-car. In this ingenious device, the load is on a platform suspended below the center of gravity, the car is cylindrical with conical ends, which rest upon the rails at either side. The track forms a series of inclined planes, the car rolling down one by gravity and up the next by the momentum acquired, and so on. Practically, however, this is quite as feasible as the others, among which we may mention: The wheel provided with 25 weights, 15 of which are constantly descending on its outer rim, while 10 are being raised in a straight line on an endless band, each ball being, in its turn, transferred from one to the other; spiral troughs or tubes, down which balls run and are received into similar and opposite spirals, whence they are returned to the first, causing rotation in opposite directions; and rocking devices, in which a ball is allowed to run down an inclined vibrating plane whose motion is automatically reversed each time the ball reaches either end.

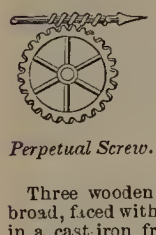
Pneumatic devices are a prominent subject. Among these is the occasionally recurring hollow cylinder, in which a weight or pressure of some kind is applied on one side of a chamber, fixed on an arm or spoke, while the air is exhausted from the other side. We believe it is the correct thing to inclose concerns of this kind in a water-chamber; at all events, this was done by Richard Varley, according to the specification of his English patent (1790), because "water has no spring."

A drum journaled in a cylinder axially divided by a vertical air and water tight partition, one side containing liquid and the other air, has also been claimed as a perpetual motor; the periphery of the wheel is provided with reservoirs containing a substance lighter than the liquid; these necessarily rise therethrough, but being heavier than air have a downward tendency on reaching that part of the cylinder which contains it. The construction of this device would appear to present some mechanical difficulties, to say the least.

The object in citing antiquated instances is to show late inventors in this line, not merely that their contrivances are fallacies, — which they are not likely to believe, — but that such are not even new, and hence, perhaps, not worth pursuing with the expectation of exclusive right, public reward, and enduring fame.

Per-pet'u-al Screw. A screw without longitudinal motion acting upon a wheel whose cogs have a pitch coincident with that of the worm.

Fig. 3649.



Perpetual Screw.

It is often used as a MICROMETER-SCREW (which see). See also WORM-WHEEL.

Per-ro-tine'. (*Textile Manufacture.*) A kind of French calico-printing machine, named after the inventor.

Three wooden blocks, 3½ to 5 feet long and 2 to 5 inches broad, faced with pear-tree wood engraved in relief, are mounted in a cast-iron frame with their planes at right angles to each other, so that each of them may in succession be brought to bear upon the face, back, and top of a square prism of iron covered with cloth and fitted to revolve on an axis between the said blocks. The calico passes between the prism and the engraved blocks, and receives successive impressions from them as it is drawn through by a winding cylinder. The blocks are pressed against the calico through the agency of springs which imitate the elastic pressure of the workman's hand. Each block receives a coat of colored paste from a woolen surface smeared after every contact with a mechanical brush. It executes about thirty pieces a day in three colors, requiring one man and three children for attendance. — URE.

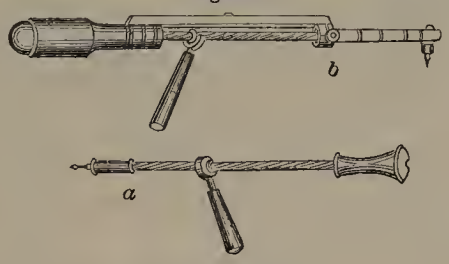
Per'sian. (*Architecture.*) A male figure draped after the ancient Persian manner, and serving to support an entablature, after the manner of a column or pilaster. *Atlantes* have a similar duty.

Per'sian Car'pet. One made in the same manner as the Turkey: usually the whole piece is set up; that is, the carpet warp is the whole width of the piece, instead of being made in breadths or strips to be joined. The web of the carpet has a warp and weft of linen or hemp, and the tufts of colored wool are inserted by twisting them around the warp all along the row. A line of tufts being inserted, a shoot of the weft is made, and then beaten up to close the fabric. See TURKEY-CARPET.

Per'sian Drill. A hand-drill (*a*) which is sometimes known as the Persian drill has a shank with a *quick* thread and a back-center in the head or handle. The nut is moved back and forth on the screw-shank, which is thus rotated, the action of the drill being rotary reciprocal.

It is frequently used for fine work and in dentistry, the shank being made of *pinion wire* twisted, and

Fig. 3650.



Persian Drills.

the spiral grooves inside the nut being made conformable to the screw-threads of the shank.

The *screw-stock drill* (*b*) is a modification of the preceding, in which the motion of the screw-stem is communicated by a pair of bevel-pinions to the drill, whose axis is at right angles to that of the driving-screw.

Per'sian Wheel. This name is given to two forms of water-raising wheels: —

1. A wheel with pots or buckets on or near its rim, dipping water at the lower part of their revolution and discharging it when they reach their extreme elevation. See BUCKET-WHEEL; CHAIN-WHEEL.

The wheel is sometimes driven by the current acting upon vanes.

2. A wheel with chambers formed by radial or curved partitions, dipping water as their edges are submerged, raising it, and discharging it near the axis.

These are both common in Oriental countries. Travelers mention them as running in Persia, Arabia, Syria, Palestine, Egypt, Spain, Tyrol. The first is here treated under NORIA (which see); the second under TYMPANUM (which see).

Per-spec'tive-glass. (From *prospective*, i. e. *prospect-glass.*) The terrestrial or land telescope, which has two more lenses than the astronomical telescope, so as to show objects in the right position.

"After dinner I to the parish church, and there did entertain myself with my perspective-glass up and down the church, by which I have the great pleasure of seeing and gazing at a great many very fine women; and what with that, and sleeping, I passed away the time till sermon was done." — PEPYS's *Diary*, 1667.

Per-spec'tive-in'stru-ment. A mechanical contrivance to assist persons in drawing in perspective.

A *camera-lucida* or *camera-obscura* will enable a perspective delineation. See CAMERA-LUCIDA; CAMERA-OBSCURA.

Bevis's perspective-instrument, described by Ferguson, consists of a rectangular board with a hinged movable frame of an arched shape, and having two adjustable strings, which may be made to intersect each other and assume any direction. The eye steadily beholding an object, say the pediment of a building, the strings are brought into coincidence with the required lines of the object; the frame is then laid down on the board, the point or lines marked on the paper, and, the frame being raised, another point or line is observed and similarly transferred to the paper. The observations are taken through an eye-piece,

which may be approached to or receded from the frame, according to the scale of the drawing required.

Ronalds's perspective-machine, patented in England, has an eye-piece and an arrangement by which a bead traversing in the plane of delineations is made to confer a corresponding motion upon a pencil.

A perspective-instrument for drawing the outlines of any object in perspective was invented by Dr. Christopher Wren, about 1669, and is described in the "Abridgment of Phil. Trans.," Vol. I p. 325.

Per-spec'to-graph. An instrument for the mechanical drawing of objects in perspective. The object is placed in front of the eye, which is applied to a small hole. A movable hinged bar is so adjusted as to bring a point between the eye and a certain part of the object. The bar is then folded down and the mark transferred to the paper. A series of such marks afford data for the drawing of the object.

Pes'sa-ry. (From the Greek *pessos,* a round stone used in playing at checkers.) An instrument in the form of a staff, ring, or ball, made of elastic or rigid materials, and introduced into the vagina to prevent or remedy the prolapse of the uterus.

The variety of these is very great, — ring, oval, globular, horseshoe shaped. Made of gold, silver, hard and soft rubber, ivory, boxwood, etc.; solid, hollow, inflatable.

They may be classed as, —

A rigid body pushed into position, and of a nearly solid or of a skeleton form. The pessary of Hippocrates was a pomegranate pierced through the core.

A ring or frame which is supported by resting against the os pubis.

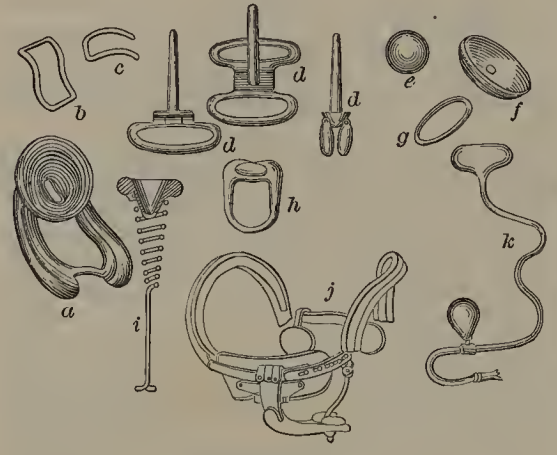
A staff or finger which is supported by an external brace or truss, and enters the vagina so as to form a seat for the uterus.

An inflatable ball or annulus, which is expanded after reaching its sphere of action.

Several kinds are shown in Fig. 3651.

a is Fraser's pessary of hard rubber, having a cup for the cervix and a supporting bow which passes down the posterior walls of the vagina, the lower portion resting upon and being supported by the levator ani muscle near its attachment to the

Fig. 3651.



Pessaries.

os pubis. The entire posterior or convex portion of the bow resists the action of the downward tendency of the uterus in the cup, while the bladder pushes the anterior wall of the vagina into the concavity of the bow, which in turn is so constructed that it clasps the parts, and is thereby aided in keeping its position. Room is provided for the urethra in the notch at the base of the instrument.

b is Hodge's double-S or closed lever.

c is Hodge's horseshoe pessary.

d is Conant's two-winged pessary of hard rubber.

e is a globular pessary of silver or glass.

f, a concave or cup-shaped, of any material.

g, a ring-shaped, made of watch-spring covered with gutta-percha.

h, the concave, perforated disk forms a support for the parts affected, while the lower loop affords a means for its introduction and withdrawal, as also a support for it while in place.

i, the india-rubber pessary is cup-shaped, with a heavy curved lip, and is supported by a spiral spring with a rod and ring for external attachment.

j is Banning's uterine supporter attached to an abdominal supporter, a curved finger extending up the uterus, whose cervix rests in the cup at the extremity.

k is an inflatable rubber globe.

Pes'tle. 1. An implement used in braying substances in a mortar.

Its use is more ancient than that of the mill. In the Bible, and in the remains of Egypt, Nineveh, and the later civilizations of Greece and Rome, it, in connection with the mortar, was a favorite mode of grinding grain for bread, as well as preparing other articles of food and medicine. See BREAD.

Being smaller and more fragile than the mortars, not so many of them have been recovered from the débris of ancient civilizations. See MORTAR.

2. The vertically moving bar in a *stamping-mill.* A *stamp.* See STAMPING-MILL.

3. The pounder in a fulling-mill.

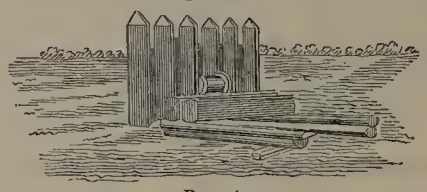
Pe-tard'. A box or bag filled with powder, used for blowing open gates, doors, etc. It is provided with a slow-burning fuse, and to produce any considerable effect should be charged with at least twenty pounds of powder. The effect is increased by loading the petard with sand-bags or other weights. A shell of large caliber may be used for the same purpose.

The effect of petards is nearly proportional to the square of the charge of powder they contain.

Disks of gun-cotton, designed to be simply attached to a stock, drawbridge, gate, or barricade, have lately been used with great effect upon experimental structures.

Powder or gun-cotton petards are placed in position for firing in the manner shown in Fig. 3652, in which the petard is laid against the stockade which it is desired to breach, resting upon timbers to give the petard greater resistance. A simple way of

Fig. 3652.



Petard.

holding the bursting-charge to its work is by a diagonal brace with its upper end holding a powder-bag against the barrier, and the other resting in a slight depression in the ground.

The invention is ascribed to the Huguenots in 1579. Those first used were of metal, in the shape of a hat, and were employed to blow up gates or other barriers, and also in countermines to break through the enemy's galleries. The petard was formerly fixed to a plank called a *madrier.* Cahors was taken by Henry IV., by means of petards, in 1580.

Pet-cock. 1. (*Steam-engine.*) A little faucet at the end of a steam-cylinder, to allow the escape of water of condensation. It is kept open until the engine is fairly under way, and is then shut.

Fig 3653.

Pet-Cock.

2. A *test*-cock.

3. A valve or tap on a pump.

Pe'ter-sham. (*Fabric.*) A heavy and fine woolen goods for men's overcoats, the face being rolled so as to present the appearance of little tufts.

Pe'tong. (*Alloy.*) Chinese white copper; an alloy of copper and nickel. *Packfong.*

Pe-tro'le-um. A liquid, inflammable, bituminous substance, composed of hydrogen and carbon.

Among the distillates of petroleum are, —

Carbon oil, 59° B and downward.

Benzine, 59° to 64°.

Naphtha, 64° to 70°.

Gasoline, 70° and upward.

Paraffine is also one of the products of petroleum.

Petroleum in various forms was known in most remote antiquity. The Egyptians used it in embalming their dead. The Jews employed it as a cementing material for their edifices, and the inhabitants of ancient Memphis covered the lower parts of their dwellings on the outside with asphaltum in order to preserve them from the dampness of the surrounding soil. The present petroleum well of Zasynthus, one of the Ionian Islands, was known to Herodotus, more than 2,000 years ago.

Pliny says: A bituminous oil is found on a spring at Agrigentina in Sicily, the waters of which were tainted by it. The inhabitants of the spot collect it on the panicles of reeds, to which it very readily adheres, and make use of it for burning in lamps as a substitute for oil; as also for the cure of itch-scab on beasts of burden.

He remarks that the inflammable material found at Samosata was used by the inhabitants to defend themselves against the army of Lucullus; that it would burn on water, and is only extinguished by earth.

In Crawford's "Embassy to Ava," published about 1826, appears the following: "Petroleum wells supply the whole Burman Empire with oil for lamps and also for smearing wood, to protect it against insects and particularly against the white ant. Its consumption for burning is said to be universal, until its price reaches that of the Sesamun oil, the only other kind used for lamps. The wells, which occupy a space of 16 square miles, vary in depth from 200 to 250 feet; the shaft is square, not more than 4 feet on each side, and is formed by sinking wooden frames The oil, on coming up, has a temperature of 90° Fah. It is thrown into a large cistern, in the bottom of which are small apertures for the aqueous parts to drain off, when the oil is left for some time to thicken. It is then put into large earthen jars, placed in rude carts drawn by oxen, and carried to the banks of the river, from whence it is sent by water to all parts of the empire."

He estimates the amount transported by the number of boats engaged in the traffic, their usual load, and the time occupied in an average trip. He puts it at 45,556,400 pounds per annum.

James Young, of Glasgow, undertook the refining of a mineral oil found in a coal-mine in Derbyshire in 1847. Having exhausted his supply, he turned his attention to the distillation of a sort of bituminous shale, known as boghead cannel, from which he extracted an oil which was an excellent lubricant and quite well adapted to illuminating purposes. His sales in England amounted to £100,000 in 1854, and in the same year a refinery, operating under his patent, was established in New York for the distillation of Nova Scotia cannel-coal. A number of coal-oil factories were soon after started in various parts of the United States.

The usual process of coal-oil distillation was by placing cannel-coal in retorts similar to those of gas-works and distilling at a moderate temperature.

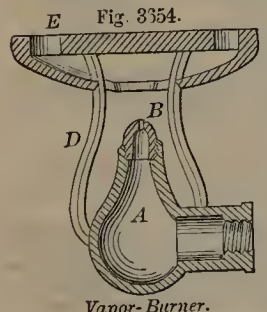
Natural petroleum had been known to exist in Pennsylvania since a date prior to the war of the Revolution, and in Ohio and West Virginia it was well known, but was considered worthless or a nuisance. The use of Young's coal-oil led to the belief that the natural oil might have a value, and about 1857 efforts were made to bring what was then known to a market, and to discover other supplies. As soon as it was found that artesian wells in the oil-regions would furnish crude petroleum, thousands of wells were sunk, and the supply is now considered inexhaustible, although the annual production fluctuates considerably. See Oil-well.

The annual production of crude petroleum in the United States now reaches at least $20,000,000, and in its refined state it has a value four times as great. The export of petroleum and its products in 1872 was over thirty million dollars.

Pe-tro'le-um-burn'er. A burner contrived to vaporize and consume liquid petroleum fed to it from a reservoir.

In Fig. 3654, the oil from an upper tank is admitted to the chamber *A*, where it is vaporized, and, issuing from the nozzle *B*, is inflamed, heating the plate *E*; this is supported upon two arms *D*, which conduct the heat downward and maintain the chamber *A* at a temperature sufficiently high to vaporize the oil. Apertures in the plate *E* conduct the flame to the base of a vessel placed above it.

Fig. 3654.

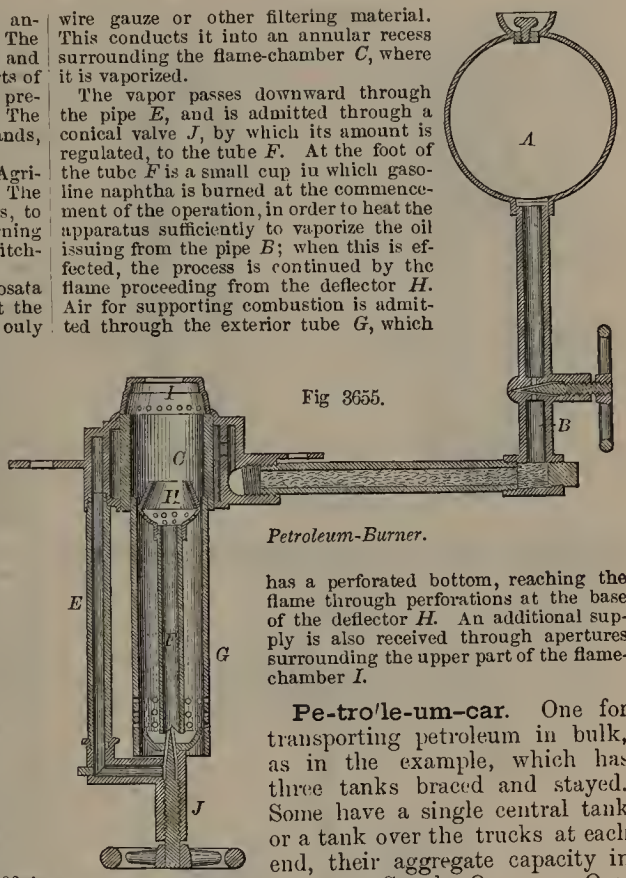


Vapor-Burner.

In the burner, Fig. 3655, the petroleum from a reservoir *A* is permitted to flow through the pipe *B*, which is provided with a conical regulating valve, and has a horizontal branch containing wire gauze or other filtering material. This conducts it into an annular recess surrounding the flame-chamber *C*, where it is vaporized.

The vapor passes downward through the pipe *E*, and is admitted through a conical valve *J*, by which its amount is regulated, to the tube *F*. At the foot of the tube *F* is a small cup in which gasoline naphtha is burned at the commencement of the operation, in order to heat the apparatus sufficiently to vaporize the oil issuing from the pipe *B*; when this is effected, the process is continued by the flame proceeding from the deflector *H*. Air for supporting combustion is admitted through the exterior tube *G*, which has a perforated bottom, reaching the flame through perforations at the base of the deflector *H*. An additional supply is also received through apertures surrounding the upper part of the flame-chamber *I*.

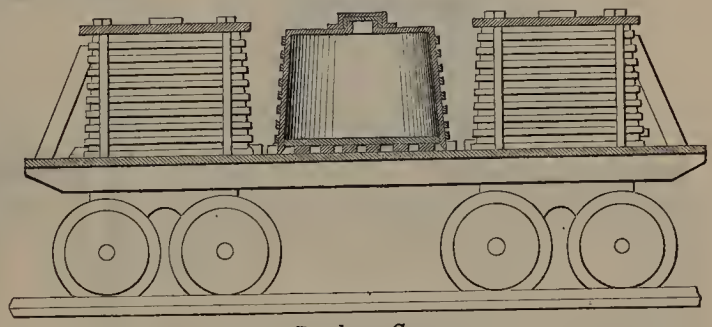
Fig. 3655.



Petroleum-Burner.

Pe-tro'le-um-car. One for transporting petroleum in bulk, as in the example, which has three tanks braced and stayed. Some have a single central tank or a tank over the trucks at each end, their aggregate capacity in either case being the same. See also Oil-car; Oil-tank.

Fig. 3656.



Petroleum-Car.

Pe-tro'le-um-fil'ter. One for removing dirt and foreign matter from petroleum.

They are of several kinds.

The tank with filtering material in a false bottom, which acts as a strainer.

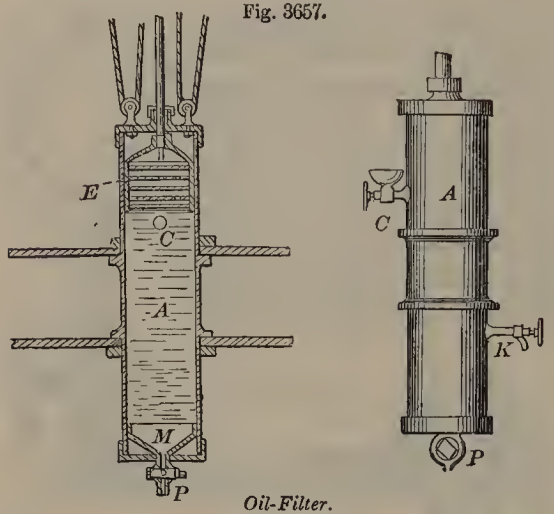
The centrifugal filter, which acts on a similar principle to the sugar-filter shown at Figs. 1213, 1214, page 514.

The piston-filter, wherein the piston forces before it the foul matter, the oil escaping through the foraminous folds of the piston.

Fig. 3657 is a piston-filter. The oil is admitted to the vessel *A* through the pipe *C*, and the filtering piston *E* is caused to descend; the impurities are forced downward by the piston and collect in the funnel-shaped false bottom *M*, while the pure oil passes through the piston, and, collecting above it, is drawn off by the cock *K*. The impurities below the piston are removed through the cock *P*.

Fig. 3658 is a centrifugal filter. The oil is placed in a wire-gauze vessel *C*, lined with two thicknesses of fabric between which layers of filtering-paper are interposed. Rapid rotation is imparted by means of the axial shaft *A* and gears *H I*, causing the purified oil to be thrown off in the form of spray and

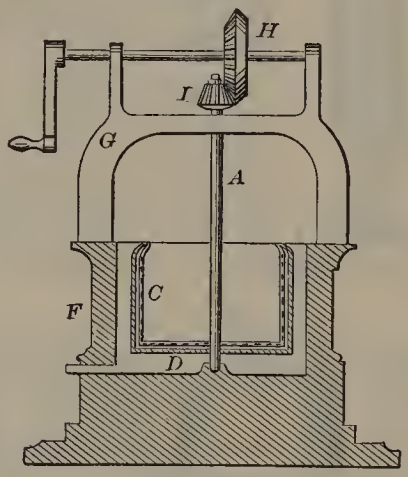
Fig. 3657.



Oil-Filter.

received in the cylinder *F*, while the impurities are retained by the filtering material. See also page 1550.

Fig. 3658.



Centrifugal Filter.

Pe-tro'le-um-fur'nace. A steam-boiler furnace constructed for burning jets of petroleum, or a spray of petroleum mixed with a proportioned stream of air, sometimes accompanied by a steam-jet.

In some cases the steam under pressure is made to lead in the petroleum and atmospheric air in the manner of the *Giffard injector* One in use in Paris has an oil-distributing device consisting of a pipe with branches, and of a grooved grate along which the oil flows after dropping from these tubes. A wrought-iron cistern contains the supply of petroleum, and is connected to the distributor by an india-rubber tube. The grate is placed vertically; the air, passing between its bars, supplies the oxygen for the combustion of the petroleum vaporized by the heat of the fire. The petroleum is supplied to the grate a little in excess of the requirements of the furnace, and the surplus drops into a receiver, and is volatilized by the heat of the furnace and the vapor consumed.

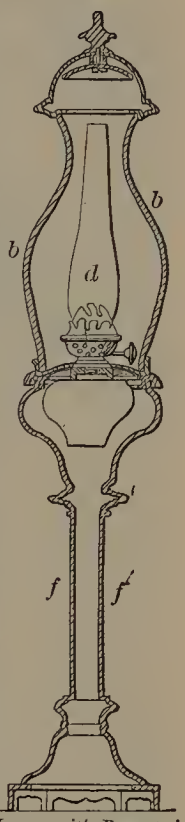
Pe-tro'le-um-lamp. A lamp for burning coal-oil. See list under LAMP for varieties.

The lamp (Fig. 3659) is particularly designed for use where, as in hot climates, a strong artificial current of air is produced by fans or punkahs. The reservoir with its chimney *d* is supported on a hollow pillar *f f*, and is surrounded by a shade *b b* covered by a cap, so that access of external air is prevented, except through perforations at the base of the pillar, which admit sufficient to support combustion. Suitable orifices in the cap permit the escape of the hot air. The burners, two or more in number, have flat wicks, but may each form a segment of an ellipse or circle.

Pe-tro'le-um-still. A still for separating the hydrocarbon products from crude petroleum, etc., in the order of their volatility.

In Kelley and Tait's continuous distillation apparatus (*H*, Fig. 3660), oil from the tank *a* passes through the pipe *b* to the upper retort *c* of a series arranged within the furnace *d* and connected by overflow-pipes *e*, through which it successively flows from one to the other. Steam introduced into the furnace through a pipe *f* entering near its top passes downward, and, becoming superheated, enters the retorts through the pipes *g g*, by which they are connected with the upcast branch of the pipe *f*, causing the vaporization of the oil. The vapors pass through the pipes *h h* into the chamber *i*, in which water from the tank *k* is admitted through rose nozzles in the form of spray. The lighter vapors pass off through the chimney *l*, in which a shower of water from a rose nozzle serves to condense those which are less volatile. Water accumulating at the bottom of the condenser *i* passes off through the overflow-pipe *m*, the supernatant hydrocarbon liquid being withdrawn through the pipe *n*. A glass gage *o* at the side of the chamber indicates the hight of the oil and water contained therein. If it be desired to rectify the oil without the use of steam, the cocks of the pipes *h* are closed, with the exception of the uppermost, so that the vapors pass upward through the series of overflow-pipes *e'* to the top retort of the series before being discharged into the condenser. The lowermost retort or retorts are provided with discharge-cocks *p*.

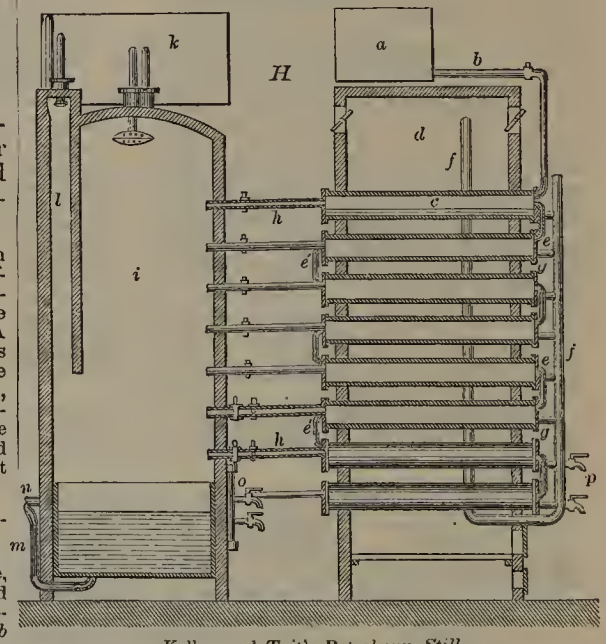
Fig. 3659.



Lamp with Protected Burner.

Lockhart and Gracie's still (Fig. 3661), in which *A* is a vertical and *B C* horizontal sections, has the still *a* surrounded with a hot-air space *b*; it is heated by a plurality of fire-chambers *c c c c*, divided by walls *e e e e*, from which the products of combustion pass over bridge-walls *d d d d* before entering the chimney *e*; this is provided with a damper *f*. The interior of the still is provided with a stirrer, shown in detail at *C*; this consists of a ring *h* carrying arms *i i*, to the lower part of which scrapers *k k* are attached, which remove the tarry sediment or residuum from the bottom of the still, discharging it into a pipe by which

Fig. 3660.

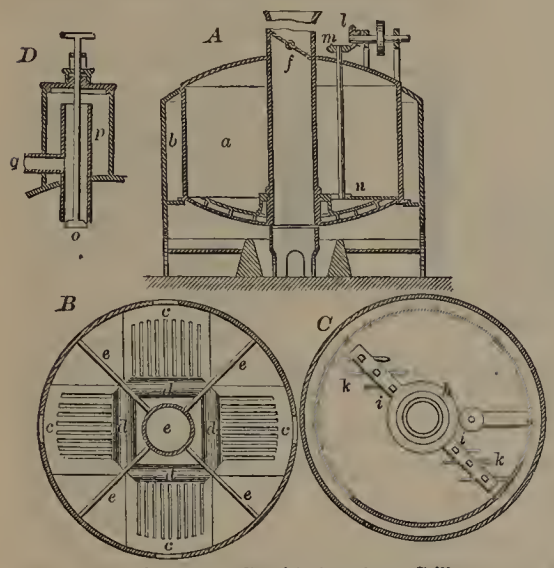


Kelley and Tait's Petroleum-Still.

it is withdrawn into a reservoir. The arms are rotated by a set of gears *l m n*, the last of which meshes with the toothed ring *h*.

D is a pipe at top of the still into which the lighter vapors of distillation, naphtha and benzine, pass directly when the valve *o* is closed, at the beginning of the operation, flowing down the pipe *p* and out through *q* to the condenser: when the flow of the lighter products has sensibly diminished, the valve *o* is

Fig. 3661.



Lockhart and Gracie's Petroleum-Still.

opened and the heavier products rise through the lower end of the pipe *p* and pass to the condenser.

Rogers's still (Fig. 3662) is designed to perform the series of fractional distillations required to separate the various products evolved from hydrocarbon oils by a continuous operation. *a* is the retort, which is filled with liquid through the charging-pipe *b*, and heated in any suitable manner. From the retort the vapors pass to the column *c*, having a series of compartments c^1 c^2, etc., one above the other, filled to a certain hight with the liquid to be distilled by means of a pipe *d*, having valves so that any number of the compartments may be filled; it may also be used for drawing off the liquid when required. *e* is the worm; it is surrounded by a tank containing water, and is connected at one end to the pipe *f* and at the other to the pipe *g* by valved openings. The lower bends of the worm are connected by pipes to the lower cooling worms *h h'*; these pipes have valves by which the fluids condensed in the upper worm may be diverted into the pipe *i*.

Heat being applied to the retort *a*, the vapors evolve, pass through the pipe *a'* into the column *c*, and ascend successively through the various compartments, the heavier portions and impurities being condensed in the liquid contained therein, while the lighter portions pass on to the worm *e*, where the less volatile vapors are condensed and the liquid is drawn off into the auxiliary or cooling worms *h h'*; or, if it is desired to run the liquid or any portion of it back into the column or the retort, one or more of the valves of the worm-connecting pipes are closed, and the liquid flows into the pipes *j j*. The worms *h h'* are so arranged that the liquid supplied them may be of different grades, as, for instance, *h* receiving that from the three first coils of the worm, which are of lower grade than those condensed in the next three coils, and which are received in the worm *h'*, and so on. When it is desired to run only the highest grade of liquid, all that is condensed in the worm *e* may be run back into the column or retort and again distilled, that vapor only which is uncondensed by the worm *e* passing over through the pipe *g* to be condensed in a worm contained in the tank *k*; or only the vapors which are not condensed by the right-hand turns of the worm may be passed over, the remainder being returned to the retort.

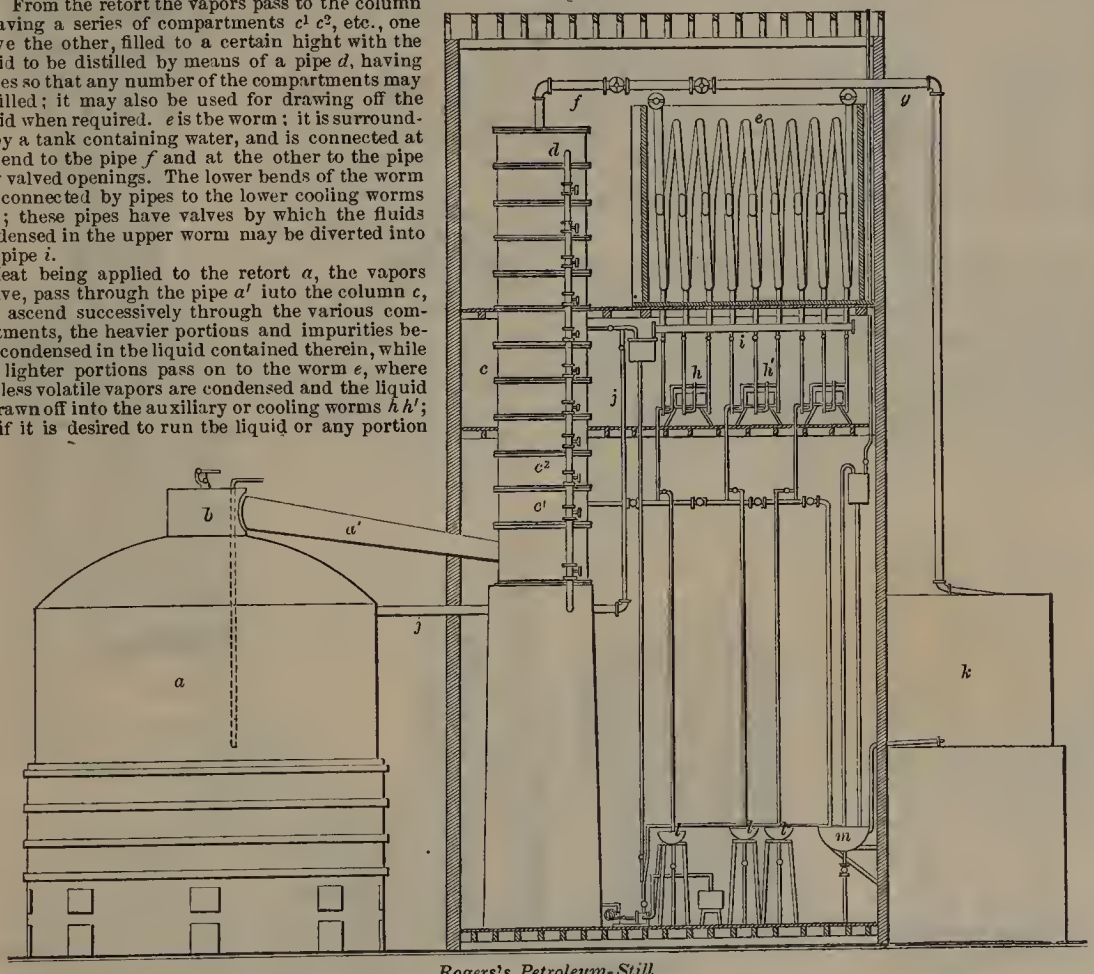
The most volatile vapors may require pressure or cold artificially produced, in order to condense them; for this purpose the coil in the tank *k* may be surrounded by ice or other cooling mixture, and pressure applied by an air-pump arranged to work either as a vacuum or pressure pump; any remaining uncondensible vapors are carried off into the air or burned.

The liquid from the pipe *i* passes into a water-trap which is provided with a pipe for drawing off the water. *l l l* are running pans for receiving the liquids from *h h'*, etc., and *m* the main running pan.

Carpenter's apparatus (Fig. 3663) is designed for generating a permanent illuminating gas from petroleum. The oil from a tank *C* is admitted through a valved pipe *D* to the boiler *A*, where it is volatilized and conducted through the pipe *h* to the retorts *F F F*, by which the gas is superheated and rendered non-condensible.

The amount of vapor generated in the boiler is indicated by a gage *a*, and if this is in excess of the capacity of the retorts *F* the surplus is conducted into the tank *E*, where it is condensed and reconducted to the boiler *A*. The gas from the retorts *F* is then passed through a cooler *I* into a purifier *J*, provided with a series of foraminous diaphragms containing lime or other substance for absorbing impurities, and is finally received in the gasometer *K*, where it is retained until required for use. *B G* are grates for heating the boiler and retorts.

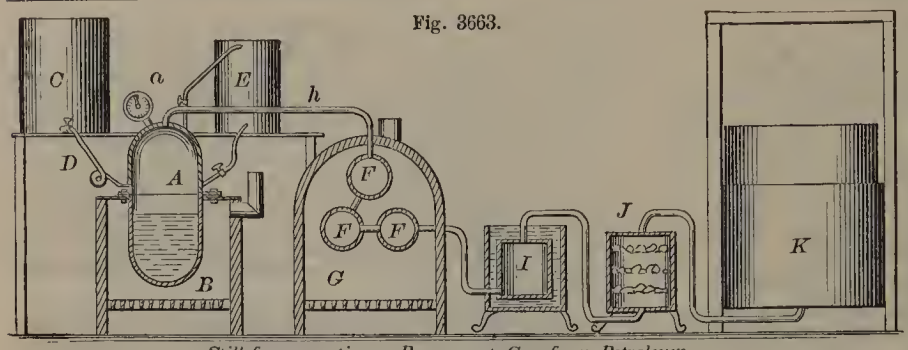
Fig. 3662.



Rogers's Petroleum-Still.

In the invention of Olney, 1874, and St. John, 1874, the petroleum is vaporized by steam coils in the still or the jacket around it, so as to leave no residuum. This vapor is then mixed with ordinary coal-gas of low illuminating power, and passed slowly through a highly heated retort to make permanent gas.

Fig. 3663.

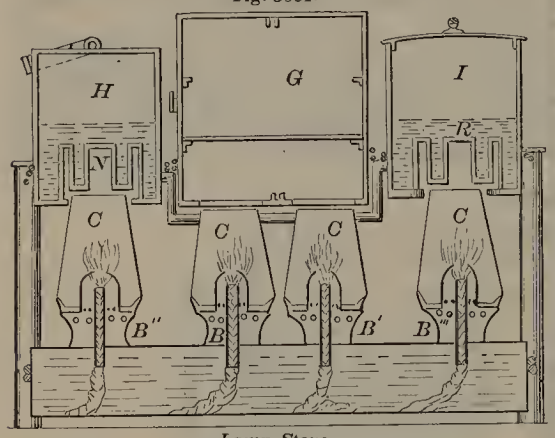


Still for generating a Permanent Gas from Petroleum.

Pe-tro'le-um-stove. One in which the heat is derived from the burning of coal-oil, usually in lamps, but sometimes in pans.

In Fig. 3664, the burners *B B' B'' B'''* have sheet-metal chimneys and mica doors, so that their combustion may be watched and regulated. The bottoms of the boilers *H I* have peculiarly shaped chambers *N R*, to expose a large surface to the heat. The oven *G* has removable vertical partitions dividing it into compartments, each of which may be heated independently in case it is not desirable to have more than one burner lighted.

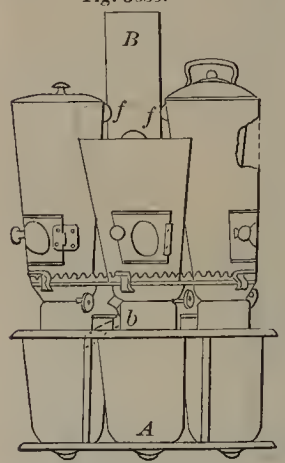
Fig. 3364.



Lamp-Stove.

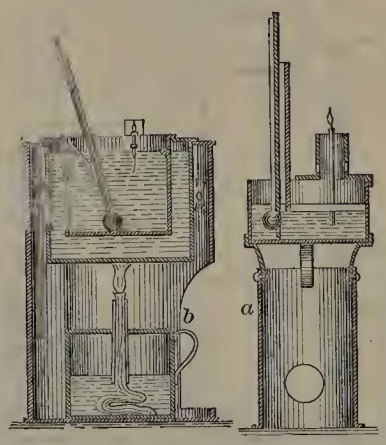
In Fig. 3365, a series of oil-reservoirs are arranged between two horizontal plates, and may be turned around on rollers so as to present either in front. The vapors formed over the surface of the oil in each reservoir are conducted by pipes *b* into the lower part of the chimney *B*, beneath a wire-gauze diaphragm, to prevent danger of explosion. The burners of the reservoirs are within sheet-iron vessels of inverted conical form, adapted to receive cooking-vessels, and provided with mica doors; the products of combustion are conducted by pipes *f f* into the central chimney *B*. See also Fig. 1359, page 581.

Fig. 3665.



Coal-Oil Cooking-Stove.

Fig. 3666.



Petroleum-Tester.

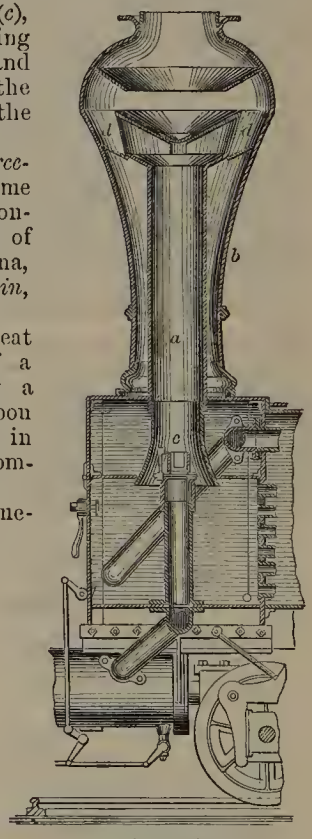
Pe-tro'le-um-tank. See OIL-TANK.

Pe-tro'le-um-test'er. An instrument for determining the inflammability of illuminating oils, or of inflammable matter in compound liquids, by means of a thermometer and a flame, the thermometer being applied to the liquid while the heat is imparted to the latter, and the vapor generated by the heat being directed to the flame, so as to take fire when the heat rises to the point at which the liquid gives off explosive vapors. The illustration shows Smith and Jones's (*a*) and Tagliabue's (*b*) devices for this purpose. See also Millochan, September 5, 1865; Tagliabue, October 28, 1862; Hartshorn, June 29, 1869.

Pet'ro-nel. A grade of cannon in some services, 6-inch bore and 24-pound ball.

Pet'ti-coat-pipe. (*Steam-engine.*) A pipe (*a*) in the chimney (*b*) of a locomotive, which comes down over the exhaust-nozzle (*c*), and conducts the escaping steam and the smoke and sparks which follow the induced current into the arrester *d*.

Fig. 3667.



Petticoat-Pipe.

Pe-tunt'ze. (*Porcelain.*) The Chinese name of a feldspathic rock containing an admixture of quartz, and used in China, when mixed with *kaolin*, for making *porcelain*.

Pew-chair. A seat affixed to the end of a pew so as to occupy a part of the aisle upon occasion when seats in excess of the pew accommodation are required.

Camp-chairs are sometimes used, but the *pew*-chair is a specific folding-seat attached to the pew.

Pew'ter. 1. An alloy of tin and lead, to which other metals are sometimes added. The lead is sometimes entirely replaced by other metals. Its most common use is for cheap table-ware, tankards, beer-mugs, etc., though it is also employed, when containing a little copper, in making toy musical instruments; from it are also made polishing-laps for jewelers and other articles. The plates

from which cheap music is printed are frequently made of pewter, the notes being stamped instead of cut, as is done in copper-plate engraving. When a large proportion of lead is used it constitutes tinman's solder.

The usual proportion of lead in pewter of good quality is from 16 to 20 per cent. Any excess over this tends to impart a dull, bluish appearance. Hardness and sonorousness are imparted by the addition of a little copper; by substituting antimony for the copper, hardness and a silvery luster are produced. If, during the process of melting, the contents of the pot are stirred with a strip composed of equal parts of zinc and tin, or a lump of zinc is allowed to float on the surface, the formation of dross is prevented; hence it is said to "cleanse" the mass.

The following are some of the formulas given.

Common: tin, 4; lead, 1.

Better: tin, 112; lead, 16; copper, 6; zinc, 2.

Hard pewter: tin, 192; antimony, 16; copper, 4.

Best pewter: tin, 100; antimony, 17.

Aiken's: tin, 100; antimony, 8; copper, 4; bismuth, 1.

Manufacturers consider that a better article is produced by melting up old pewter with new ingredients; when this is done analysis alone can determine the proportions of each metal in the alloy. See ALLOY.

The English pewterers have three varieties, *plate*, *trifle*, and *ley* pewter.

The *plate*-pewter has, tin, 100; antimony, 8; bismuth, 2; copper, 2.

The *trifle*-pewter has, tin, 83; antimony, 17; with a good deal of lead occasionally.

The *ley*-pewter consists of, tin, 4; lead, 1.

Some inferior varieties contain nearly 50 per cent of lead. To remedy this debasement and establish a uniform standard, the English Pewterers Company attempted in 1772 to regulate the quality by comparison of its weight with that of a given bulk of tin; for this purpose a button of pure tin weighing 182 grains was employed; a similar button of *plate*-pewter would weigh 183½ grains; of *trifle*, 185½ grains; and of *ley*, 198½ grains; equal parts of tin and lead weighing 232 grains. Their rule, however, was not much regarded.

The finest pewter, frequently called *tin* and *temper*, is produced by adding *temper*, composed of 2 parts tin and 1 copper, in the proportion of from ½ to 7 pounds to each pig of tin weighing from 360 to 390 pounds.

Owing to the liability of lead to corrosion when exposed to vinegar, sour fruits, etc., the French government appointed a commission to determine what amount of lead is admissible in *pewter*. They determined that 82 parts of tin might safely be alloyed with 18 lead. A standard was then adopted, of tin, 83.5, lead, 16.5, with a tolerance of 1.5 per cent to allow for unintentional errors.

The density of the legal standard is 7.764.

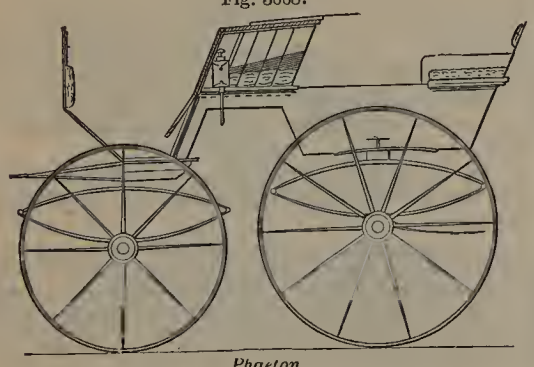
Pewter vessels are fashioned by hammering, as in the case of plates and dishes, or by casting them in brass or bronze molds which are formed both inside and outside of pieces suitably locked together. The inner surfaces of the molds are oiled, or smeared with gum-sandarach and white of egg. The cast pieces are then chucked, turned, and polished. Soft solder is used for uniting the parts. See SOLDER; WHITE-METAL ALLOYS; MOCK-SILVER; BRITANNIA-METAL.

2. A polishing material used by marble-workers and derived from the calcination of tin.

Pew'ter-er's Sol'der. It is of three grades, termed *hard pale*, *soft pale*, and *middling pale*. The first contains 2 parts tin and 1 lead; the second, 2 lead, 1 tin, and 1 bismuth; the third a middle grade.

Pew'ter-er's Tem'per. An alloy of 2 parts tin and 1 copper; from ½ pound to 7 pounds of this are added to a block of tin weighing from 360 to 390 pounds to produce the finest kind of pewter, frequently called *tin and temper*.

Fig. 3668.



Phaeton.

Pha'co-cys'tec-tome. An instrument adapted for Rognetta's operation for cataract, by cutting out a portion of the capsule of the crystalline lens.

Pha'co-pis. (*Surgical.*) A lenticular-shaped scalpel.

Pha'e-ton. (*Carriage.*) An open four-wheeled carriage, usually drawn by two horses.

Phan-tas'ma-go'ri-a. An optical effect produced by a machine similar to a magic-lantern, except that instead of the figures being painted on transparent glass, the glass is painted black on all parts except that occupied by the figures, which are painted in transparent colors, and all the light transmitted is through the figures. The image is thrown upon a screen of thin silk placed between the spectators and the lantern. By moving the instrument towards or from the screen, the figures are made to diminish or increase in size.

Dissolving views are produced by the employment of two lanterns of equal size and power, so arranged that the circle of light transmitted from each shall fall upon the same part of the screen. A perforated plate with a crescent-shaped opening is adjusted so that as light is admitted to the slider of one lantern it is shut off from the other, the first picture disappearing as the second becomes illuminated. See DISSOLVING VIEW.

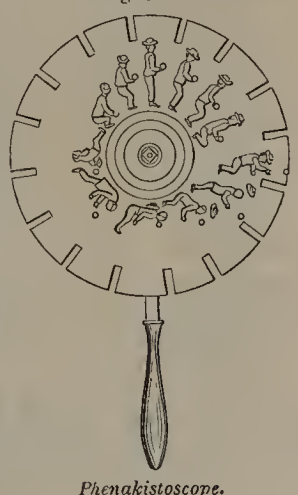
Phan'ta-scope. An instrument invented by Dr. John Locke of Cincinnati, to illustrate some phenomena of binocular vision. It consists of a flat board with an upright rod at one end, with two adjustable thimbles, like those of a retort-stand. The upper one supports a card with a slit 3 inches long and ¼ inch wide, so as to admit both eyes to look through it. The other thimble supports a second card with a slit, and an index marked across its middle. By an adjustment of the second card, a pair of objects on the base-board is viewed through the perforations of both cards, and by viewing the index the optical axes of the eyes are converged and the objects are reduplicated, and eventually a merged image appears in the central position. *Phantasmoscope.*

Pha'ros. A LIGHTHOUSE (which see).

Pha-ryn'go-tome. (*Surgical.*) An instrument to scarify inflamed tonsils and open abscesses in the parietes of the pharynx. It has a long, narrow blade with a lancet point, inclosed in a slightly curved silver sheath, in which it is carried to the part to be cut, and from which it is made to protrude by pressing a button at the end. The blade is retracted by a spring.

Phe'na-kis'to-scope. Invented by Dr. Roget. Improved by Plateau and Faraday. This instrument, which, like the *thaumatrope* and *zeotrope*, depends upon the persistence of visual impressions, consists of a circular disk on which a row of figures are painted in a series of attitudes such as would be consecutively attained in the progress of an action; for example, leaping, walking, swimming, etc. The effect is to produce the appearance of actual motion. The disk is placed on a handle and rotated by the finger on a nut. It is held in

Fig. 3669.



Phenakistoscope.

front of the observer, the face of the toy toward a looking-glass, and the figures are viewed through the slits.

Phi'al. A small bottle used chiefly for medicine.

Pho-nau'to-graph. Or *phonograph.* An instrument, invented by Leon Scott, which automatically records phonetic sounds by diagrams in a manner analogous to that in which the indicator-diagram of a steam-engine records the pressure of the steam.

It proceeds upon the premises, that articulate sounds are accompanied by the expulsion of air from the mouth; that the impulses vary in pressure and duration and in the suddenness with which they commence and terminate; that different syllables vary in volume, force, continuity, and abruptness.

Professor Barlow uses a speaking-trumpet about 4 inches long, having an ordinary mouth-piece connected to a tube, which has an end expansion of 2½ inches diameter, which is covered with a membrane of gold-beater's skin or gutta-percha. A spring rests gently against the membrane, and carries a light arm of aluminium, which holds a small sable brush, forming a marker which touches a traveling strip of paper, registering the vibrations of the diaphragm which agree with the characteristic force, persistence, and celerity of the enunciated syllables. See "Popular Science Review," London, July, 1874. Also Silliman's Journal, August, 1874, pp. 131, 131.

Charles A. Morey, Massachusetts Institute Technology, suggests as a mode of increasing the excursion of the *marker* to have the shorter end of a lever in contact with the membrane, the larger one to carry the style or marker. The effect is to magnify the motion.

The future of this instrument, which is at present little more than an acoustic toy and apparatus for the lecture-room, is undetermined. It would be possible to so connect the style with electrical devices that its excursions, both as to distance and continuity, might be exactly repeated at any distance by the telegraphic circuit; or the diagram might become a record capable of transmission by the autographic or automatic plans; or the instrument might be made to operate a type-writer, and so the spoken words might become a record printed in ordinary letters on paper.

Pho'no-graph. An instrument in which the tracer is moved by the vibration of a circular stretched membrane, which is itself excited by sonorous waves proceeding from any sounding body, as a bell, a diapason, a musical instrument, or the human voice. In order to intensify the impulses upon the membrane, this is fixed in the focal point of a large hollow paraboloid, truncated at the apex. The sounding body is placed in front of the paraboloid, and the receiving cylinder is brought into a convenient position at the opposite extremity to receive the trace. Also known as a *phonautograph.*

Pho'no-scope. An apparatus for testing the quality of musical strings, invented by M. Koenig, and shown at the International Exhibition, in 1862.

Phos'phor Bronze. An alloy of copper, tin, and phosphorus capable of being made tough and malleable, or hard, according to the proportion of the several ingredients. It is rendered so liquid in the molten state by the addition of the phosphorus, that it forms very clean castings. At the London International Exhibition it was shown in the form of bearings of machinery, cog-wheels, guns, cartridge-cases, wire, and tuyeres for blast-furnaces, hammers, knives, scissors, hinges, locks, keys, bells, netting, sieves, wire for pit-ropes, and plates for the sheathing of sea-going ships.

Messrs. Levi and Kunzel, of the Val Benvit Nickel-Works, near Liege, Belgium, have, for a number of years past, been engaged in making experiments for the purpose of improving bronzes of this kind. The results of their experiments are thus summed up by M. Dumas: —

"The color, when the proportion of phosphorus exceeds one half per cent, becomes warmer and like that of gold largely mixed with copper. The grain and fracture approximate to those of steel. The elasticity is considerably increased, the absolute resistance under a fixed strain becomes more than doubled; the density is equally increased, and to such a degree that some alloys are with difficulty touched by the file. The metal, when cast, has great fluidity, and fills the mold perfectly to the smallest details. By varying the dose of phosphorus, the particular characteristic of the alloy which is most desired can be varied at will."

In a series of experiments at the Royal Academy of Industry at Berlin, a bar of phosphor bronze (proportions of components not stated), tried under a constant strain of 10 tons per square inch, resisted 408,230 pulls of that amount, while a bar of ordinary bronze broke before the strain of 10 tons to the square inch had been attained. A bar of phosphor bronze, under a strain of 10 tons, resisted 862,980 bends, while the best gun-metal broke after 102,650 bends. Another bar, tested under a strain of 9 tons, has resisted 1,260,000 bends without breaking. In Austria the following comparative results have been obtained: —

Absolute Resistance.

Phosphor bronze . . .	81,798	pounds per square inch.		
Krupp cast-steel . . .	72,258	"	"	"
Ordnance bronze . . .	31,792	"	"	"

The best English copper sheets lost, during six months' immersion in sea-water, 3.058 per cent; phosphor-bronze sheets but 1.158 per cent.

The composition of several alloys of this class is given in the following table: —

	Copper.	Phosphorus.	Tungsten.	Zinc.	Nickel.	Tin.	Lead.	Bismuth.	Arsenic.	Antimony.	Brass.	Manganese.	Mercury.
Parke's Eng. Pat. (12,325 of 1848) for sheathing boilers, etc.													
No. 1	95	3–5											
2	95	1-2	3–5										
3	€0	2–5		38									
4	€0	5		40	20								
For casting in molds.													
No. 1	5	5				60	20	5					
2	2	5				25	25			5			
3	2	3		45		50							
4	2	3				10	50		5				
Parke's Eng. Pat. (2,996 of 1857) for sheathing.*	240	1		160									
	400											1-1.5	
	400										400		1 5 1
Parke's Eng Pat. (5 of 1858) for wire or tubes	100	.5											
Lavroff, U. S. Pat. (Aug. 22, 1871)	80	1				19							
Levi & Kunzel† (May 23, 1871)	89.9	1.6				7							
	92.5	.5				7							

* Phosphorus added in the stick to the melted copper.

† Phosphorus added in the form of phosphuret of copper or tin, and while the alloy is covered with a reducing layer of carbon cast in chilled molds smeared with petroleum.

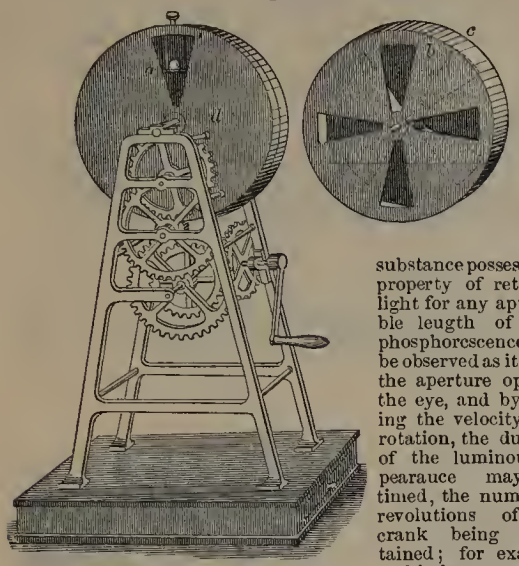
Phos-phor'o-scope. 1. A philosophical toy, the "trap to catch a sunbeam," consisting of glass tubes arranged in a box and containing phosphorescent substances, as the sulphides of lime, strontium, barium, etc. When this is exposed to the sun's rays or to the light emitted by a gas-burner or burning magnesium, and then removed to a dark place, each tube appears to glow with light of a different color, as red, blue, green, etc.

Another mode of displaying this property in certain substances is by spreading them in thin layers on a dark surface; these may be formed into any desired fanciful figures or representations of natural objects whose images may often be presented in their natural colors by a judicious selection of the phosphorescent materials.

2. An instrument devised by Becquerel for measuring the duration of phosphorescence in different substances.

A crystal of fluor spar or other substance to be examined is placed in a cage *a* between the two perforated screens *b c*, which are rotated within the casing *d* by a hand-crank and gearing. The casing has two apertures on opposite sides, so arranged that the rays from an electric light behind it shall not pass through, but are admitted to the crystal once during each revolution. The interior screens may be rotated at a high velocity, when, if the

Fig. 3670.



Becquerel's Phosphoroscope.

substance possesses the property of retaining light for any appreciable leugth of time, phosphorescence will be observed as it passes the aperture opposite the eye, and by slowing the velocity of its rotation, the duration of the luminous appearauce may be timed, the number of revolutions of the crank being ascertained; for example, if this be turned once in a second, and a train of three multiplying wheels and pinions with teeth in the proportion 100×100×100 to 10×10×10 be employed between it and the screeus, the latter will be rotated at the rate of 1,000 times per second.

In this way it has been found that many substances previously thought non-phosphorescent are capable of retaining light for very short periods.

Phos'pho-rus-paste. A poison for rats, mice, roaches, etc.

Take 8 ounces of common starch and pour over it 1 pint of water; stir and thcu pass through a No. 60 sieve into an enameled dish capable of holding a gallon, and add 1½ pints of water and 24 ounces of flour. Mix thoroughly, introduce 24 fluid ounces glycerine, and heat on a sand-bath, stirring constantly. When a plasma begins to form, take it from the fire, but continue stirring. After a few minutes reapply heat, stir, and set aside to cool. Mix 6 ounces of the plasma gradually with 8 ounces water in a porcelain measure, and set in nearly boiling water. When hot enough, drop in 2 drams of phosphorus. When this has fused, agitate the whole thoroughly and introduce as much more phosphorus, repeating the operation until 2 ounces of phosphorus have been added. After this, thicken the phosphoric emulsion with more of the reserved plasma, and finally incorporate it thoroughly with the remainder. Preserve in small, wide-mouthed bottles, protected from the air.

Pho'tics. That department of science which treats of light. The term originated in the United States Patent Office, and is there applied to that class of mechanical inventions embracing lamps, gas-light arrangements, and illuminating apparatus generally.

Pho'to-e-lec'tric Lamp. A name for the electric lamp.

Fig. 3671 illustrates the electro-magnetic safety-lamp invented by MM. Dumas and Benoit for miners' use. The generating cell and helix are inclosed in a case provided with a strap, by which it may be slung over the miner's shoulders. The helix wires pass through insulatiug tubes to an illuminating coil within the glass lamp cylinder, which prevents access of fire-damp to the lamp. See SAFETY-LAMP.

Fig. 3671.

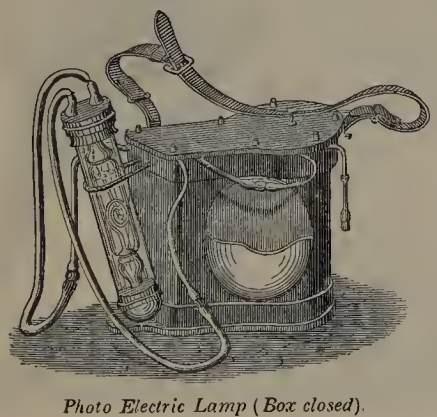


Photo Electric Lamp (Box closed).

Pho'to-e-lec'tro-type. (*Photography.*) A process in which a photographic picture is produced in relief so as to afford, by electro-deposition, a matrix for a cast, from which impressions in ink may be obtained. See PHOTO-GALVANOGRAPH, etc.

Pho'to-en-grav'ing. 1. A name applied to each of many processes, in which the action of light on a sensitized surface is made to change the nature or condition of the substance of the plate or its coating, so that it may by processes be made to afford a printing surface corresponding to the original from which the photographic image was derived. The processes are divisible into PHOTO-INTAGLIO, PHOTO-RELIEF, and WOODBURYTYPE.

2. The photographic process is also used for obtaining a picture upon a plate or block for subsequent engraving. The value of the process consists in the quickness and the fidelity of the picture. In some cases it is a substitute for an offset or tracing process, in other cases it affords a means of obtaining a picture from nature or from a model.

In this relation occurred one of the most remarkable patents on record for what it failed to do; that of James Palmer, England, No. 13,736, of August 23, 1851. The object was to use gelatine as a vehicle for receiving delineations of objects. 1. The sheet of gelatine was placed in a frame, in the manner of a pane of glass, between the eye and the object, and the outline of the object was traced upon it. "Various methods of reducing, enlarging, multiplying, and transferring are thus obtained." 2. The sheet was treated with chemicals, especially alum, to render it insoluble in water, in order that *wet* paper might be employed in taking from it impressions to act as transfers. 3. The design might be deeply scratched upon it in manner of an etching, and the gelatine used as a copper-plate, the lines to hold ink which furnished an impression in a press. 4. This impression was to be transferred to stone or zinc for printing by the lithographic process; or to copper or wood for engraving by the usual tools. 5. It might be colored yellow by bichromate of potash. 6. It was to be placed in a camera obscura in order that an image might be thrown upon it. 7. The engraved gelatine was to be used as a matrix for casting or electrotyping.

Without any apparent intention here were suggestions of a *photogelatine process*, *gelatine lithographic-transfer*, *photolithography*, and a host of *photo-relief* and *photo-intaglio processes*. He needed but to have exposed the sheet of bichromated gelatine to the action of light, and then applied ink and water, to have anticipated all the above inventions and reached a result which would have very much surprised him.

In the Chandler process as an aid to engraving: —

The surface of a polished plate of copper is blackened by a sulphuret of potassium and coated with a ground of resiu, wax, and sulphate of lead. The surface is sensitized and an image thrown on and fixed. The lines are followed by an etching-point or graver down to the black copper surface. The plate is treated with graphite and then a film of copper deposited on it in a bath. This is backed for printing. See RELIEF-LINE PROCESS.

The following process is adopted for photographing on wood for engraving purposes: —

The box-wood block is first dampened with water, then whitened with enamel from visiting-cards. The dry whitened surface is flowed with a solution of albumen, made with the white of one egg and 16 ounces of water. When this is dry coat it with a filtered solution of the white of one egg; water, 4 ounces; chloride of ammonia, 40 grains. Dry this by a gentle heat.

Prepare a solution of ether, 1 ounce; alcohol, 1 ouuce; guncotton, 8 grains; nitrate of silver, 30 grains dissolved in as small a quantity of water as possible. Mix and allow to settle for a few days, protected from the light. Flow the block as previously prepared in the dark room, and dry by gentle heat. Expose under the negative in a printing-frame. After printing, the last composition is removed from the surface of the block by dissolving in ether and alcohol, assisted by rubbiug gently with a soft sponge. The picture can now be toned and fixed in the ordinary way, or fixed and toned at one operation, by the hypo. and gold bath. After being allowed to dry, it is ready for the engraver.

Pho'to-gal-van'o-graph. (*Photography.*) A process for producing printing-plates in relief by the consecutive actions of light and electro-deposition.

As invented and practiced by Pretsch in 1854: Take a posi-

tive photographic print on paper or glass; cover a sheet of glass with bichromated gelatine; when dry, lay the positive upon it and expose to light. Develop by immersing in water; where the light has not acted the gelatine swells and the parts where the light has acted do uot absorb water, and are sunken relatively. Take a mold iu gutta-percha, which gives an intaglio. Take a plate by treating the surface with graphite followed by electro-depositiou, which gives a matrix like the gelatine. Take a cameo electroplate from the matrix, which gives a plate to be priuted from by the ordinary printing-press.

For metallic ornamentation. It has been suggested that the surface of a metallic objeet being polished or frosted, a film of iodide of silver be formed on it, and an image from a negative thrown upon the object in a camera. Being placed in an electro-bath, a deposit of copper takes place on the parts exposed to light, while the unexposed parts, protected by the shadows of the negative, receive no deposit of copper. The object is now dried, etched with a solution of sulphuric acid, saturated with nitrate of potash. This attacks the silver and not the copper. When the silver is corroded the required depth, the copper is removed by aqua regia, which does not affect the silver. The surface previously protected by copper is in relief, and corresponds to the lights of the negative, the dark lines of the print, for instance, from which the negative was obtained.

Pho'to-gel'a-tine Pro'cess. One in which gelatine, prepared chemically, usually by the bichromate of potash, is made to receive a photographic image, which may become a printing-surface or be transferred to a stone or zinc to form a printing-surface thereon.

The term may be used to distinguish those processes employing gelatine, from those in which starch, gum, asphaltum, etc., are used.

The processes are various. For early items on this subject, see GELATINE PROCESS. See also ALBERTYPE; HELIOTYPE.

Gelatine Processes. a. The drawing or print being in lines or dots, a negative on glass is obtained. From this a print on a film of bichromated gelatine is obtained, and this, after suitable treatment, is transferred to stone and rolled up for printing. Osborne's process. See PHOTOLITHOGRAPHY.

b. A photographic positive on glass is placed over a sheet of talc bearing a film of bichromatized gelatine. This being exposed to the light, through the talc, the gelatine is hardened, according to the intensity of the transmitted light, leaving unaltered the parts in perfect shadow. The film being washed in hot water, the unaltered gelatine is dissolved away, leaving an intaglio plate in gelatine, in which the depressions correspond to the light portions of the picture. A cast forming a cameo in metal is obtained by electro-deposition or by a press, giving a printing-surface in relief. A peculiar ink is used, consisting of gelatine holding coloring matter, the degree of depression determining the quantity of ink and consequent depth of tone. The WOODBURY PROCESS (which see).

Pho-to-gen'ic Draw'ing. A picture on paper by the agency of light on a sensitized surface. See PHOTOGRAPHY.

Pho-to-glyph'ic En-grav'ing. See PHOTOGLYPTIC-ENGRAVING.

Pho-to-glyp'tic En-grav'ing. A process invented by Mr. Fox Talbot, October 29, 1852, in which a design was so produced on metallic plates as to form a printing-surface.

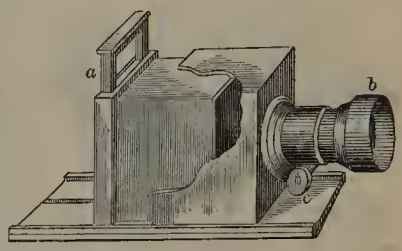
A solution of gelatine, 1 part, water, 40 parts, is mixed with 4 parts of a saturated solution of bichromate of potash. The mixture is floated over a plate, giving an exceedingly thin film, and allowed to dry in the dark. Being exposed in connection with a print in a frame to sunlight, its surface is strewed with finely powdered copal, which is melted by the aid of heat. The plate is then etched by a solution of perchloride of platinum or perchloride of iron, which attacks only the parts unacted on by the light. When a sufficient depth is attained, the etching liquid and the ground are washed off, and the plate, after cleaning, is employed for printing. In place of the surface of copal he used, before exposure, fabric to cut up the flat tints by intercepting the light and enable them to hold the ink. The ingenuity of the process depends a good deal upon the selection of the solvent which dissolves the metal without effervescence, penetrating the unaltered gelatine and preventing its disturbance by the evolution of gas.

Pho'to-graph-e-nam'el. A process of transforming photographic plates into colored enamels. Two methods are employed. In the first, introduced by De Camarsac of Paris, colored vitrifiable powders are applied with the pencil to the different parts of the proof on glass, and the whole is raised to the necessary heat in a muffle. In the second, that of Tessié du Motay and Maréchal of Metz, the photographic proof, taken in the ordinary way, but made as forcible as possible, is immersed in solutions of other metals by which the silver is displaced. If this be done successively in several baths, with exposure of different parts of the device in each, the subsequent process of enameling will furnish corresponding varieties of tint.

Pho-to-graph'ic Cam'e-ra. (*Photography.*) A chamber in which a sensitized surface, usually a glass with a film of sensitized collodion, is exposed to the actinic action of light. See PHOTOGRAPHY.

In photographic operations different forms of cameras are used, named according to the construction, purpose, or the conditions under which the picture is being taken; such are *box*, *bellows*, and *stereoscopic*, *field* and *studio*, *copying*, *enlarging*, and *solar* cameras, etc.

Fig. 3672.

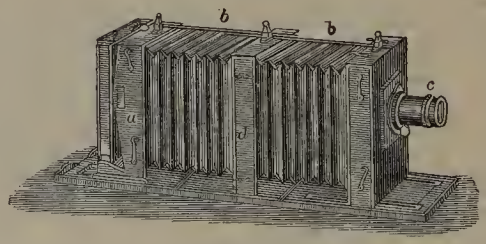


Box-Camera.

Fig. 3672 is a *box*-camera, an early and yet very useful form. One portion slides telescopically in the other, to regulate the size of the image, which bears a certain proportion to the relative distances of the plate and the object from the lens. *a* is the plate-holder; *b*, the lens-holder; *c*, a rack adjustment for focus.

Fig. 3673 is a *bellows*-camera, in which the portion of the chamber holding the lens *c* and that containing the plate-holder

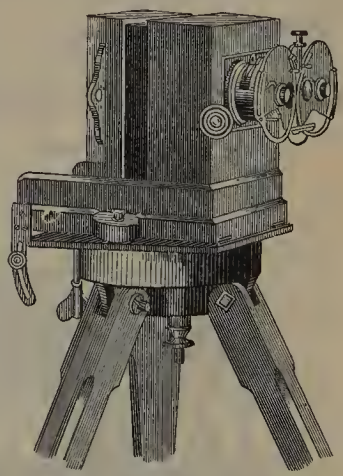
Fig. 3673.



Bellows-Camera.

a are united with a central rigid portion *d*, by expansible portions *b b*, which are like the bellows of an accordeon, and thereby permit the adjustment of the distance of the plate from the lens. The plate-holder portion has also a rocking adjustment, so as to allow the face of the plate to be brought parallel with the general plane of the object being copied. The great advantage of the bellows is the compactness of the device for transportation when collapsed. The bed portion is hinged so as to be doubled up.

Fig 3674.

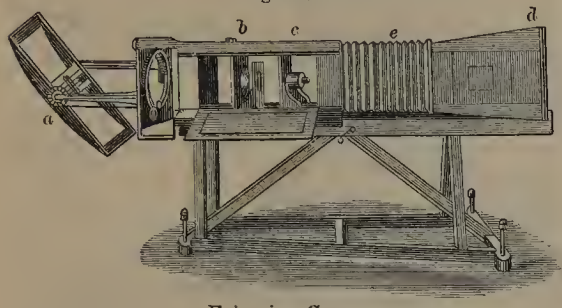


Stereoscopic Camera.

Fig. 3674 is a stereoscopic camera used for field work especially, having an arrangement for instantaneous exposure of the two lenses, which admit pencils of beams to the plates in the binary chamber. Shutters are placed in front of each tube, so arranged that, by the touching of a spring, they are simultaneously rotated, bringing for an instant of time a hole in each shutter in correspondence with the tube, admitting rays of light from the object to the sensitized surfaces in the interior.

Fig. 3375 is a form of copying and enlarging camera having a reflector *a* for directing the rays into the interior, which is shown exposed by letting down the door forming a portion of the side. *b* is the position of the negative; *c*, of the lens; *d*,

Fig. 3375.



Enlarging-Camera.

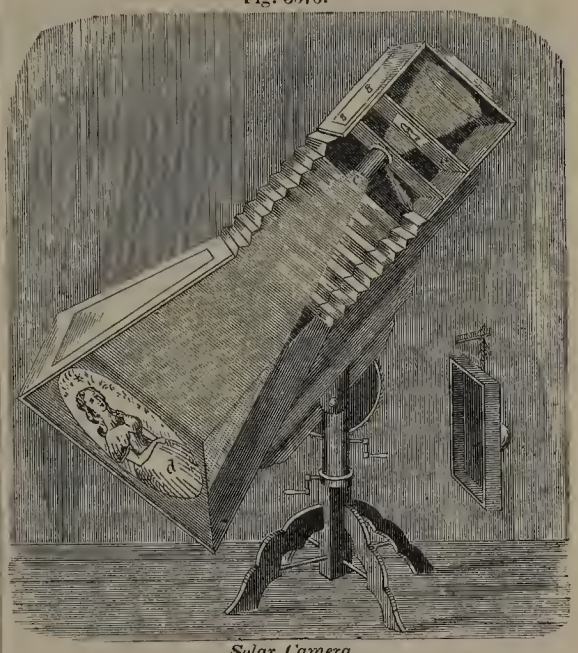
of the sensitized paper on which the positive enlarged print is obtained. The negative and lens are adjustable by sliding in the chamber; the paper holder by the bellows *e*.

Fig. 3376 is a view of a solar camera for enlarging by sunlight. *a* is the adjustable partition having a central aperture at which the negative is exposed to the rays entering at the window *b*. *c* is the lens; *d*, the board for the paper enlargement.

J. W. Osborne's copying-camera and table is unique in the respect that it combines the camera and its support by a rigid and permanent connection with the *plan-board*, upon which the object to be copied is exposed. The whole apparatus is portable, and in use is adjustable on casters for horizontal direction, and by a rapid screw for inclination, so as to give the required presentation of the plan-board in order that it may take the light from the sky, and not from secondary, and usually vertical, reflecting surfaces.

Fig 3377 shows the instrument as seen obliquely from the back of the plan-board, in its tilted position. The table *a* consists of a truss-frame, hinged upon the ridge of a truck *b*, to which the casters are attached. In use, the casters are lifted from the floor, throwing the weight of the truck upon rubber blocks *d d*, 10 or 12 inches high, the object of which is to cut

Fig. 3376.

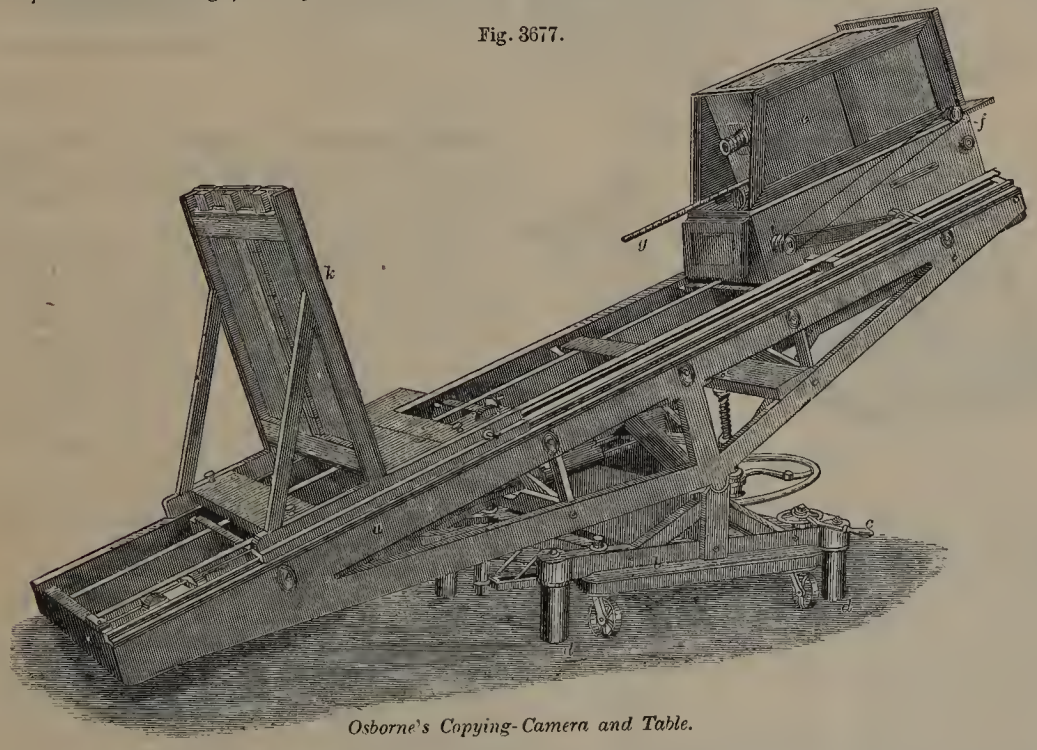


Solar Camera.

off vibration. This is done by moving a handle *c* and ratchet, which by means of an endless chain act upon all the casters at once, either in raising or lowering. The truck also carries the step of the double-threaded screw, used for tilting the table. The screw passes through an oscillating nut in the table.

The camera *e* rests upon a hollow block, which raises its axis to a convenient hight as regards the plan-board. Unlike ordinary cameras, it consists of a single trunk permanently attached to its place at the end of the table. The back part of this *camera-box* has a rabbet to receive the *focusing-screen*, and afterward the *dark-slide*, or *plate-holder*. The other end is cut

Fig. 3377.



Osborne's Copying-Camera and Table.

to a bevel, and has a double-flap door hinged to its lower edge, for the purpose of shutting off the light until all is ready for the exposure of the sensitized plate. The bevel at the end stands nearly perpendicular when the camera is tilted. Inside the camera-box is a sliding *lens-holder*, moving on V's for adjustment. The joint is made *light tight*, without occasioning friction, by a broad strip of soft fur, let into a shallow rabbet around the lens-holder. The fur extends against the sides of the camera-box and perfectly excludes the light, leaving sufficient clearance. The motion is effected by an endless steel belt passing over small metallic pulleys at either end of the trunk, and controlled by outside milled heads *f* on a shaft passing through the pulley and across the box, conveniently presented to the operator. This original method of focusing by thin metallic belts has the advantage of affording a means for rapid and positive movement, being free from back-lash and yet having great delicacy. It affords a means for rapid adjustment on either side of the problematical focus, enabling the eye to use its

power of comparison under the most favorable circumstances. The measuring-rod *g* is attached temporarily to the lens-holder and slides through a notched disk also removable; its object is to indicate the position of the lens-holder or restore it to an old position. The rod and disk are removed while the negative is being made. The pulley *i* and belt afford a means of adjusting the position of the lens while watching the graduated rod

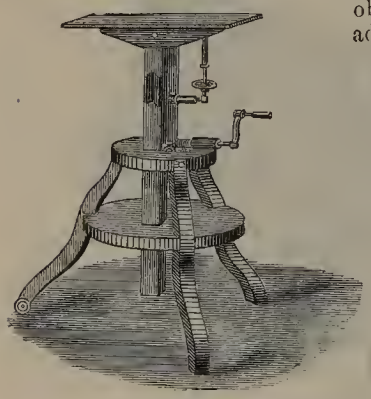
The plan-board *k* stands at right angles to the plane of the table, is adjustable longitudinally on the same, and can be firmly clamped in any position. The adjustment is by a steel belt passing over pulleys at both extremities of the table; the pulley at the camera end being provided with a horizontal capstan arrangement and lever, so that the position of the plan-board is under the control of the operator while inspecting the focusing on the ground-glass screen. The position of the plan-board on the table is indicated by a pointer traveling along a graduated scale. The plan-board consists of a number of narrow slats fitting into rabbets on the inner edge of its frame, each slat being held in its position by a single screw in its center passing into the middle back-bar of the frame; any warp occurring is therefore in detail, and does not affect the general plane.

The table is always brought to a horizontal position in focusing, the end of the camera-box being covered by a hood under which the operator stands. So placed, he controls both the positions of the plan-board and the lens, and has the ground glass always at a constant distance from him. In copying at or near full scale, the position of the lens affects the size of the picture, making little change in the sharpness of the focus, which latter operation is then done with the plan-board. When a large reduction is required, the position of the plan-board affects the size, and the focusing is done with the lens. It will be observed, that the lens is placed far back in the box, never advancing to its end save for enlargements; it follows, therefore, that for the great mass of work required, the accidental rays, which might otherwise fall upon the lens, are excluded. This object is farther accomplished by a rectangular diaphragm, falling into the bevel end of the box behind the door when the latter is closed.

The construction of an instrument of this kind must be very exact, so as to maintain the parallelism of the plan-board, the lens-board, and the ground-glass screen in all positions of the table. The first instrument of the kind was constructed by Mr. Osborne in 1833, for the American Photolithographic Company, at their works in Brooklyn, N. Y. The length of the table is 14 feet; width, 4 feet; plan-board, 4 × 5 feet.

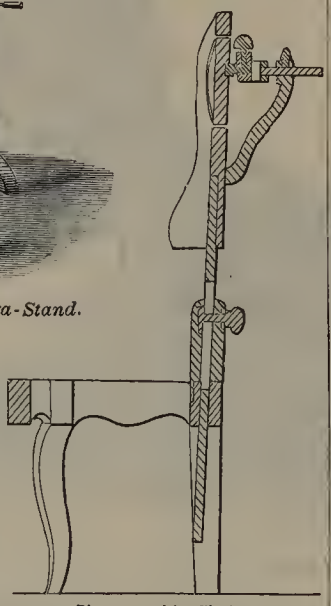
Pho-to-graph'ic Cam'e-ra-stand. (*Photography.*) A table to support a camera, having adjustments for hight and inclination, and obtaining its lateral adjustments by moving about with facility upon casters.

Fig. 3678.



Photographic Camera-Stand.

Fig. 3679.

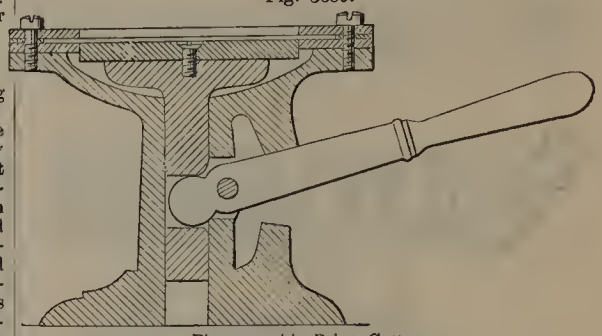


Photographic Chair.

Pho-to-graph'ic Chair. (*Photography.*) A chair arranged for posing a sitter. The example shows a back vertically adjustable, and a head-rest which works through an opening in the chair-back.

Pho-to-graph'ic Cut'ter. (*Photography.*) An instrument for cutting the margins of photographic prints. It is a substitute for trimming-scissors. The example consists of a die-punch worked by a lever from below two metallic plates, perforated in the form required for the photograph, which is placed between the plates with the face upward.

Fig. 3680.



Photographic Print-Cutter.

Pho-to-graph'ic Head-rest. (*Photography.*) A frame with adjustable and extensible rods for the support of the head, arms, or other parts of the person, to hold them rigid during operations.

Fig. 3681.

Photographic Head-Rest.

Pho-to-graph'ic Mi-crom'e-ter. A system of opaque or transparent lines photographically reduced from a series of large and well-defined lines impressed mechanically or otherwise upon the object from which the photograph is taken, and placed in the focus of the eye-glass of a telescope or micrometer.

Pho-to-graph'ic Print'ing. (*Photography.*) The process of obtaining positives on sensitized paper from transparent negatives by exposure to light in a printing-frame.

Paper treated with certain salts of silver darkens on exposure to light. If certain parts of such paper are shielded or screened from the light, these parts will remain white, and the remainder will darken and form a picture. This, by protecting certain parts and allowing light to act on others, is what the photographic negative does. When the picture has been thus formed, it requires to be *fixed*, to prevent the farther action of light. See PHOTOGRAPHY; PRINTING-FRAME; SILVER-PRINTING.

Pho-tog'ra-phom'e-ter. An instrument for determining the sensibility of each tablet employed in the photographic process, in respect to the amount of luminous and chemical radiation.

Pho-tog'ra-phy The art of producing pictures of natural scenes and objects, or of copying delineations and multiplying them, by the agency of light.

Photography depends upon the chemical or molecular changes which the rays of light effect or excite in certain substances. It is now known that a great number of bodies are *photo-chemically sensitive* in a greater or less degree, but some of the salts of *silver*, and of *chromic acid* in conjunction with organic matter, are preëminently so, and are used practically to the exclusion of all others.

The fact was noticed by the alchemists, that *horn silver* (fused chloride of silver) suffered discoloration by exposure to the sun's rays; but the Pomeranian chemist, Sheele, in 1777, was the first to consider philosophically the *action of sunlight upon certain compounds of silver*, and especially to draw attention to the activity of the *violet and blue rays* as compared with the rest of the spectrum.

Ritter, in 1801, proved the existence of *dark rays* beyond *the violet end of the visible spectrum*, by the power they possessed of blackening chloride or silver.

Wollaston also published some experiments on the changes which light produced in *gum-guaiacum*, corroborating Ritter's views as to the activity of invisible rays.

Wedgwood, the great potter, was the first person who made any attempt to use sunlight for *copying or delineating objects*. In 1802 he contributed a paper to the Journal of the Royal Institution of England, entitled "An Account of a Method of copying Paintings upon Glass, and of making Profiles by the Agency of Light upon Nitrate of Silver; with Observations by H Davy." He used white paper or white leather moistened with a solution of nitrate of silver, dried, and kept in a dark place. This, on being exposed to light, passed through different shades of gray and brown and became at length nearly black. When the shadow of any figure is thrown upon such prepared surface, it remains white while the exposed parts become dark, therefore a painting upon glass or an engraving used as a screen above such prepared paper or leather gave a copy the reverse of the superimposed design as regards light and shade.

The images given by the camera-obscura Davy found to be too faint to produce an effect upon paper prepared with nitrate of silver, but the *solar microscope* was used with success. All the pictures made in this way had to be carefully preserved from daylight, or the whole surface would blacken, as a necessary consequence, and neither Wedgwood nor Davy ever overcame this difficulty, or found means to *fix* such photographs and render them permanent. To Wedgwood, however, must be accorded the honor of having been the first to produce a *photograph*, in the artistic and technical sense of the word.

Dr. Thomas Young, the originator of the undulatory theory of light, published in 1804 some important researches on the chemical rays

In 1809, Gay Lussac and Thénard made the exceedingly valuable observation, that a mixture of *chlorine and hydrogen did not combine in the dark*, whereas in diffused daylight they did so rapidly, and in sunlight with explosion.

Bérard, in 1812, made a comprehensive and valuable series of investigations, which was reported on by Berthollet, Chaptal, and Biot, acting as a commission. By them the solar emanations were first regarded as consisting of *calorific*, *colorific*, *and chemical rays*.

In 1814, Joseph Nicephore Niepce, of Chalon on the Saone, directed his attention to the production of *permanent pictures* by light. He experimented privately for many years, and in 1827 presented a paper to the Royal Society of London on the subject of his invention; but as he kept his method secret, it could not, according to their laws, be received.

Niepce called his process *Heliography*, and some specimens of his art on plated copper and pewter plates are still preserved in the British Museum.

The sensitive substance with which Niepce worked was *asphaltum*, also called bitumen of Judæa, the remarkable properties of which he appears to have discovered. He proceeded by preparing a solution of the mineral pitch in essential oil of lavender; with this he coated a plate of metal or glass, and when the varnish so applied was dry, he exposed it under an engraving or in the camera-obscura. The action of sunlight for many hours was necessary before the latent image was fit for *development*, to accomplish which he used a solvent (consisting of *oil of lavender* and naphtha) for the unsunned portions of the coating

By treatment with this menstruum, the picture made its appearance, the insoluble portions of the bitumen representing the lights, and the surface of the plate the shadows of the design. A final washing with water was used to remove the traces of the solvent which covered the plate.

The work of this experimenter, judged by our present standards, was doubtless crude, but it is probable that the results he really aimed at were not limited to the making of photographs alone, but extended to the production of *engraved* or *etched plates for printing purposes*, an endeavor which justified him in continuing the use of asphaltum. It is also worthy of remark, that his discoveries formed the basis of a long series of trials in the direction of *photo-engraving* by his nephew Niepce de St. Victor and others, at a comparatively recent period; and of the earliest *photolithographic process*, in 1852, that of Lemercier, Barreswill, and Lerebours, working conjointly. From another point of view, we are justified in according him a high place as a pioneer, because his pictures might well be regarded as *carbon prints* in chemical composition, and as certainly permanent; excelling, in this respect, ordinary photographs, and ranking with the finest developments of the photographic art of the present day. No other attempt at the reproduction of carbon prints was made for thirty-five years after his time.

In 1829, M. Niepce associated himself with M. Daguerre, and no doubt contributed much to the latter's beautiful process.

In the year 1834, Mr. Fox Talbot began the investigations which finally resulted in a valuable working process. On the 31st January, 1839, six months prior to the publication of M. Daguerre's process, Mr. Fox Talbot communicated his photographic discoveries, and in the following February he published a description of his method, to which, as afterwards perfected, he gave the name of *calotype*. He prepared a sheet of paper with *iodide of silver*, by treating it alternately with solutions of *nitrate of silver* and *iodide of potassium*. When dry, and just before use, he covered the surface with a solution of *nitrate of silver* and *gallic acid*, and dried it again, by which means he greatly enhanced its sensitiveness. A very brief exposure of paper so prepared to light produced an effect which, though latent and imperceptible to the eye, was yet susceptible of development by a reapplication of the *gallo-nitrate of silver* to the surface of the sheet. When the picture produced in the camera or under a drawing or engraving was thus *developed*, it was washed with a solution of *bromide of potassium*, the effect of which was to stop all farther change due to light. It was then washed in water and dried.

A *photograph* so obtained was necessarily a *negative*, but Mr. Talbot recognized the important fact that, by the simple exposure of his calotype paper under such a negative and its subsequent development, any number of *positive* prints could be produced.

To Mr. Talbot we are therefore indebted for a method of arresting photographic action and *fixing* the image; for the conception and production of a *negative*, and the subsequent *printing* of positive prints by light; and, above all, for the discovery of the wonderful *development* of the latent image by *gallic acid*.

His process, as above given, was greatly improved by himself and others, but our space does not permit of details.

In January, 1839, the announcement of Daguerre's invention was made to the world, but no description was given until the July following, when a bill was passed in the French legislature giving him a pension of 6,000 francs, and 4,000 francs to Isidore Niepce, the son of M. Joseph Nicephore Niepce, above mentioned.

The pictures were produced on *silver plates* or upon sheet-copper plated with silver. The surface was first cleaned and polished with great care; it was then exposed to the fumes of dry *iodine* until a film of *iodide of silver* was produced upon its face. When the proper amount of iodization was obtained, known by the color, the plate was transferred in a suitable dark slide to the camera-obscura, and there exposed in the focus of the instrument to the luminous emanations passing from external objects through the lens. After a sufficient time the plate was carried back to a darkened room, and there exposed in a box of suitable construction to the *fumes of mercury*, evaporating at a low temperature, from 140° to 170° Fah. This treatment gave rise to the gradual development of a picture, the vapor attaching itself to the exposed parts of the iodide of silver in quantities proportional to the actinic action.

The picture on the plate is now to be *fixed* by immersing it in a solution of *common salt*, or, better, in one of *hyposulphite of soda*, which dissolves the unchanged iodide of silver and destroys the sensitiveness of the surface to light. The plate, after being washed and dried, is finished, but it must be covered with glass to prevent its injury by friction. The shadows of the picture so produced are formed by the highly polished silver surface, and the lights by the deposit of mercurial vapor.

Such is the *daguerreotype* in its simplest form.

It is impossible to praise too highly this beautiful and wonderful process, or the intelligence and perseverance of its inventor. Many improvements and additions were soon made, which greatly increased its practical value. These consisted in the use of *bromine vapor* conjointly with that of *iodine* in *sensitizing* the plates by Goddard, in 1839; and in the addition of *chlorine* by Claudet, in 1840: the object in both cases being to shorten the time of exposure. The success which followed these and other improvements in the art, as well as in the construction of cameras and lenses, caused the daguerreotype process to become immensely valuable in portraiture, enabling it to hold its ground in every country until displaced by collodion, about 1852 or 1853. M. Fizeau, by the application of a *solution of gold* to the fixed daguerreotype plate, rendered important service. Not only were the results greatly improved in appearance, and as works of art gaining much in brilliancy and force, but their permanency was also assured, the metallic gold replacing the finely divided mercury in part and combining with it, so that its dissipation was no longer an evil to be dreaded.

Mungo Ponton, in April, 1839, published his discovery that paper prepared with a solution of *bichromate of potash*, and dried, was sensitive to light. Without ignoring the presence of the paper, he believed that this was true of the salt itself, but Becquerel showed in 1840 that *organic matter* must be present and in intimate association with the *chromic salt*. Mungo Ponton, in his contribution to the Scottish Society of Arts, must be regarded as having laid the foundation of some of the most important photographic developments of the present day, — *photolithography*, *carbon-printing*, *collography*, and *photo-mechanical printing* generally; but in this connection it must be stated that Mungo Ponton often gets credit for more than he actually did, partly from the fact that his original article is but little known. Fox Talbot, in 1852, first made the attempt to turn his and Becquerel's investigations to practical account, in his own *photo-engraving process*.

For landscape purposes the *calotype* gave valuable results in the hands of amateurs, and it finally took its highest development in the *wax-paper processes* of Le Gray and Fenton; but until glass was used as a support for negative pictures, the business of the professional landscape photographer was a poor one.

In 1848, M. Niepce de St. Victor proposed the use of *albumen on glass* as a vehicle for sensitive salts of silver, and published his method. The value of this idea was quickly recognized,

and the process improved by others. Its success depended in great measure on the fact that albumen is coagulated and rendered insoluble by the nitrate of silver used to sensitize it, and that it dries finally to a very hard and transparent film, furnishing a negative from which positive photographs can be rapidly printed by light A consequence of this improvement was the rapid development of all *positive-printing methods* on paper.

In the brilliant series of discoveries and inventions which distinguish the history of photography, perhaps the most important in its effects was the introduction of *collodion*, which took place in 1850. To Mr. Scott Archer of London is due the credit of the *negative-collodion process*, which has made photography the most important art-industry of the world. In justice to M. le Gray, it should be added that he had previously suggested collodion as likely to be of service in photography. In the autumn of 1851, Mr. Archer published a full description of his process, which did not differ essentially from that now practiced.

Collodion is a viscid solution of gun cotton in a mixture of alcohol and ether. It flows easily on the surface of a glass plate, and *sets* quickly to a gelatinous film, which then dries to a hard, transparent, and insoluble skin, adhering closely to the glass. In addition to its physical characteristics, collodion is well adapted for photographic negatives because of its indifference, chemically speaking, to the sensitive salts, acting only as a medium or vehicle for their successful exposure under favorable circumstances and subsequent treatment Without going into the broad subject of *collodion photography*, a short sketch of its leading features is here given as at present practiced.

A sheet of *glass* of size suitable for the *negative* to be made is thoroughly cleaned by friction with alcohol and rotten-stone, or in some other efficient way. The operator lays hold of the plate, holding it in a horizontal position, and then pours steadily a quantity of *sensitized collodion* upon its upper surface; he then causes the liquid to travel successively from corner to corner of the plate without letting it pass the edge, and pours the excess off into another bottle. The plate, in its upright position, is rocked gently to and fro, so as to equalize any ridges or inequalities otherwise likely to form. By this time the collodion will have *set*, forming a gelatinous film, evenly covering the glass. When the plate is thus *coated*, it is *sensitized* by being plunged into an upright bath containing a *solution of nitrate of silver*.

The collodion used for this operation is, as above stated, a solution of gun-cotton, but it contains, in addition, certain iodides and bromides of the metals, most usually of potassium, ammonium, and cadmium, but many others are used. The changes which now take place in the gelatinous film of collodion immersed in the negative bath will be easily understood; *metallic silver* takes the place of the alkaline or other metals in the film, and forms there *insoluble bromide* and *iodide of silver*. The coating upon the plate, which was transparent when it entered the bath, is now milky, entangling in its substance the two haloid salts above mentioned.

The plate is next to be lifted from the bath (the room being darkened), drained for a few moments, inclosed in a *plate-holder*, carried to the *camera*, and exposed before the scene or model to be photographed. During this operation, the sensitive coating receives the rays of light forming the picture, as they fall upon the *ground-glass screen* used in *focusing*.

They effect there a mysterious change, the exact nature of which, whether chemical or physical, is still a disputed question among the highest authorities.

The plate having been exposed to the *actinic action* is now carried in the closed plate-holder back to the darkened room, illuminated by yellow non-actinic light only. The most careful examination of the surface will be found to show no trace of alteration, but a change has nevertheless been produced. If we pour over the surface an aqueous solution of a *salt of iron* (generally the protosulphate), to which a quantity of *acetic acid* has been added, the picture gradually undergoes development, a dark deposit forming upon all those places where the light has acted, the density of which is directly proportional to the energy of the chemical rays. To explain this beautiful phenomenon, we must remember that the collodion has brought with it from the negative bath, not only the sensitive salts of silver, but also a quantity of the nitrate solution adhering to and permeating the film In the silver solution, the protosalts of iron, even in the presence of acetic acid, which acts as a retarder, would, in the course of time, cause a deposit of metallic silver in a finely divided state. It is such a deposit which forms the negative picture upon the exposed plate when flooded with the developer, as above described; but the change produced by exposure gives to the sensitive salts the remarkable power of determining the comparatively rapid precipitation of the finely divided metallic silver upon them, in proportion to the change they have undergone. Were the free nitrate of silver washed thoroughly from the plate before exposure, the solution of iron would fail to produce a picture thereon. It will be seen, therefore, that the sensitive haloid salts do not themselves participate in the formation of the photographic image.

When sufficiently *developed*, the farther action of the solution is stopped by profuse washing of the plate with water. It is then to be fixed by flowing over it a solvent of the silver salts, a solution of *cyanide of potassium*, or of *hyposulphite of soda*; this removes the milky character of the deposit which the film received in the negative bath, leaving the picture to all appearance as though it rested upon bare glass.

The plate is now to be thoroughly washed, drained, dried, and varnished with one of the many resinous solutions manufactured for that purpose, after which it is ready for the printer.

In the foregoing description many possible and frequently used modifications have been disregarded, as tending to confuse the reader's comprehension of the phenomena, but it is necessary to mention that protosulphate of iron is not the only substance which will act as a developing agent. Notably, pyrogallic acid, which first succeeded the use of gallic acid, as discovered by Fox Talbot, held for many years the first place in the estimation of photographers for this purpose. The use of proto-iron salts was originally recommended by Robert Hunt, in 1844, and is now universal. The use of acetic acid in the developer is to retard the too rapid precipitation of the metallic silver from the mixture of developer and nitrate on the plate; but many other substances, most of them organic, can be and are employed.

To produce *positive photographic prints* from such a *negative*, the following is the method used: A sheet of paper is coated upon one side with *albumen* containing common *salt*, chloride of ammonium, or some other soluble chloride in solution. When dry, this sheet is floated, face downward, upon a solution of *nitrate of silver* contained in a shallow glass or porcelain tray. The action of the solution is twofold: it coagulates the albumen, rendering it insoluble, and decomposes the chloride contained in the same, replacing the alkaline metal with silver, thereby forming sensitive chloride of silver on the paper and nitrate of the alkaline metal in the bath. The sheet is now lifted from the liquid and dried.

A suitable piece of paper so prepared is now to be exposed under and in close contact with the finished negative. This is accomplished by pressing them together in a frame made for the purpose. (See PRINTING-FRAME.) The light passes through the negative in quantity depending on the transparency of its several parts, and produces a darkening of the silver salt in the albuminous surface proportional to its intensity. When sufficiently exposed, the color of the paper will be dark reddish-brown, almost black in the deepest shadows.

This sheet of paper is now to be taken from the printing-frame and washed in water to remove the free nitrate, after which it is subjected to the operation of *toning*. For this purpose it is immersed in a very weak solution of a *salt of gold*, the action of which is modified by an admixture of carbonate, phosphate, or acetate of soda, etc. The gold from this solution, which decomposes gradually, is taken up by the photographic image, substituting metallic gold for the metallic silver, forming the picture in the first instance. The consequence is that we obtain a much more pleasing result, and one which is, at the same time, more permanent.

As in the case of the negative, this sheet has now to be *fixed* by immersing it in a solution of hyposulphite of soda, which, by its solvent action, removes all unaltered chloride of silver from the albuminous surface.

This finished print is to be long and thoroughly washed in an abundance of pure water, then to be dried, mounted, and glazed or burnished in a suitable press.

It will be observed in the foregoing description, that no developer is required to produce the image (as in the case of the negative), the explanation of which is that chloride of silver in the presence of an excess of nitrate of silver is directly decomposed by the actinic rays, the nature of its sensitiveness being essentially different from that of the analogous iodine and bromine compounds.

In concluding this sketch of the positive printing process, it is well to remark that the coating of albumen, the chief object of which is to give structureless surface to the paper, is by no means essential, inasmuch as all the foregoing operations can be equally well performed on plain paper.

The *negative collodion process*, with its necessary supplement, the printing of positives on paper by direct sunlight, caused a rapid and thorough change in landscape photography, the natural result of the excellence of the work produced and the great facilities offered for its rapid and cheap multiplication. In portraiture, it was not so. Some time elapsed before it was possible to obtain portrait negatives with a sufficiently short exposure and of such quality as to enable them to compare favorably with the best daguerreotypes. Pending the elaboration of the negative process, the *ambrotype*, or *collodion positive*, as it was called in England, became popular and held its place for several years.

An *ambrotype* is simply a thin collodion negative on glass made with a short exposure and developed so as to produce as white a deposit as possible on the lights. Such a picture is not looked at by transmitted light, nor is it valuable as a negative; it is to be backed up with a black surface, generally a black varnish, and regarded by reflected light only. Under these circumstances it appears as a positive, the deposit reflecting and the black backing absorbing the light. Pictures of this kind are rapidly made, and finished directly from the camera, as is the case with the daguerreotype, while the cost is very much less. They are, however, very inferior to good positives on paper, and had to make way for the latter as the negative process improved.

At the present day ambrotypes are rarely to be met with, but *ferrotypes*, or *tintypes*, as they are sometimes called, are pro-

duced by a perfectly analogous process, the substantial difference being that the collodion picture is made directly upon a thin iron plate covered with a black enamel or lacquer, which protects both its surfaces from the action of the negative bath and acts the part of the black backing used in the ambrotype.

Ferrotypes are still in vogue, the quickness with which they can be produced and their exceedingly small cost making them popular with the public. Cameras provided with a large number of lenses are employed in their production.

The trouble and difficulty in the efficient working of collodion negatives out of doors created a desire for a means of preserving a collodion plate in a sensitive condition, so as to render it unnecessary to coat, sensitize, and develop the plate where the landscape is taken. Accordingly, a number of preservative and dry-plate processes have been invented. In the first class, the endeavor was to cover the wet collodion with some deliquescent substance, such as nitrate of magnesia, glycerine, etc. Such processes are troublesome and unsatisfactory, and in their turn gave way to dry-plate photography. A great many inventors have devoted much labor to this department of photography. Fothergill, Taupenot, Russell, and Wortley have all produced valuable processes, but the details are too technical and elaborate for introduction here. No dry process gives results fully equal in quality to the work from wet plates, but they offer other advantages which cannot be ignored.

As substantially different methods, by which both negatives and positives can be made, the *collodio-bromide* process by B. J. Sayce, September, 1864, and the *collodio-chloride* process by G. Wharton Simpson, about the same time, deserve mention. Sayce's was a negative process on glass; Simpson's, a positive process. Each produces an emulsion of the sensitive salts of silver in collodion, an excess of nitrate of silver being also present. A surface flooded with collodion so constituted is sensitive without a bath, and may be either exposed in the camera or printed upon with a negative. The fundamental distinction is indicated by the respective names, one using the chloride and the other the bromide of silver.

Simpson's process is much used in the production of the so-called porcelain pictures.

Notwithstanding the exquisite beauty of ordinary photographs on paper, they are subject to a reproach which takes immensely from their value as works of art, for they contain within themselves the elements of destruction, and cannot be regarded as permanent. To overcome this difficulty, efforts have been made for the last twenty years to substitute carbon and other pigments for the fugitive tints of the photograph. The first to experiment in this direction was M. Poitevin of Paris, in 1855. He used a mixture of *bichromate of potash with organic matter*, such as gum, gelatine, etc., coloring it with *lampblack* or other indestructible pigment. A paper coated with this mixture and dried suffered under a negative a change, the nature of which was to render the organic matter insoluble on the places affected by light. A subsequent washing removed the unchanged gum or gelatine from the surface, leaving more or less intact those parts of the coating on which the light had acted and rendered it insoluble, and with it the coloring matter which had been employed.

M. Poitevin patented another *carbon* process at the same time in England, which differed from the foregoing, inasmuch as a greasy printing-ink was used to furnish the color. This was applied as a lithographer or printer applies his ink to the exposed organic surface; and its retention, more or less perfectly by the design, depended upon the peculiar property which such altered organic matter possesses (for the elaboration of which we are indebted to this investigator) of *attracting and holding greasy substances* and repelling water. See PHOTOLITHOGRAPHY.

Mr. Joseph Dixon published this fact in April, 1854, and to him is due the credit of priority, but Poitevin first gave it vitality and practical importance.

Many experimenters followed M. Poitevin. The most marked improvement on his crude and unsatisfactory methods was practically made by M. Fargier, who *exposed from the back of the film*, and not from the face, as Poitevin did. He acted on suggestions made by Mr. Blair and others, who pointed out the fact that the depth to which the change to insolubility penetrated into a film or coating sensitized with bichromate depended upon the intensity of the actinic action, and when such change was superficial only, as it must be for the lighter shadows of a photograph, a subsequent washing from the face will inevitably undermine and destroy them.

Mr. Swan of Newcastle-on-Tyne made very valuable changes and improvements in M. Fargier's method, which latter, while it gave good results, was uncertain and difficult to work. Swan was, in fact, the *first to produce a carbon process* practical and admirable in all respects, which has been and is still largely used, furnishing results which fully equal and in many respects surpass the best silver prints. See CARBON PRINTING; GELATINE PROCESS.

He prepared a *sheet of paper with a coating of gelatine and carbon ueous matter* on its surface; a suitable piece of this was immersed in a solution of *bichromate of potash* and dried, by which it was rendered sensitive. After exposure, this sheet was mounted with a caoutchouc varnish, face down upon another piece of paper acting as a temporary support; the whole was then immersed in warm water, whereupon the original sheet carrying the pigmented film became detached and floated off, while the gelatine dissolved away gradually from the now exposed surface, leaving eventually the organic matter attached to the second sheet in thickness proportional to the depth to which the light had penetrated the film. It will be seen that the tint, depending on the carbon imprisoned in the altered organic matter, will also be proportional to the intensity of the light passing through the different parts of the negative, and that the finer shades will not suffer destruction as they did in Poitevin's method.

When the warm water had thoroughly developed the picture it was dried, trimmed, and again transferred by pasting it to the *mount* where it was intended to remain, the sheet employed as a temporary support being easily disengaged from the face by the application of a little benzole.

More recently (in 1870), J. B. Johnson made some useful modifications in Swan's method of working, establishing what is known as the *autotype* process.

Another photographic process, quite as distinct in its character as *carbon printing*, but comparatively of little general interest, is known as *aniline printing*, invented by Mr. Willis, England, in 1865. This method is designed for copying tracings or drawings, chiefly the former, and reproducing a few copies without alteration in scale and at little cost. Willis dispenses with the camera, glass plates, collodion, nitrate bath, etc., using only a large printing-frame. The tracing itself is used as a screen or *cliché*, under which to expose the prepared paper. The latter is placed in the printing-frame, not in contact with the drawn surface, but with the back of the traced sheet, through which the light has to pass, so as to avoid the reversing of the print. This is an expedient which necessarily takes materially from the sharpness of the result. Such a process, so restricted in its scope, would hardly deserve mention were it not that the chemical reactions involved are peculiar in their application to photography.

Mr. Willis sensitizes one surface of his sheet with bichromate of ammonia, adding also other non-essential chemicals to exert an influence on the tone of the resulting picture. After being dried in the dark, the coated paper is exposed for a short time under a positive, after which the sheet is subjected in a closed tray to the fumes of aniline diluted with benzole

The second equivalent of chromic acid in the bichromate of ammonia still existing in those parts of the coated surface undecomposed by light, reacts upon the aniline and gives rise to a dark purple-black color, which is very permanent.

It is obvious that the whole sheet would blacken in the aniline vapor, but for the exposure under the tracing, and that the action of the actinic influence is to decompose the bichromate on the parts of the sheet corresponding to the whites of the drawing, and incapacitate them for oxidizing the aniline, and thereby producing the color required to form the visible picture. A simple washing in water is all that is necessary to fix and clear up such reproductions. Aniline prints have a general greenish tinge over their whole surface, due to the presence of sesquioxide of chromium, resulting from the decomposition of the chromic acid.

In recording distinctive processes, reference should also be made to the efforts of Becquerel and Niepce de St. Victor to produce photographic pictures in color. Their labors in this direction have been considerable, with but meager results, which can hardly be said to have gone beyond a demonstration of the possibility of getting fugitive reproductions of certain colors on peculiarly prepared surfaces. A sub-haloid salt of silver is generally regarded as the sensitive substance required in their experiments.

In addition to the foregoing might be enumerated many mechanical printing processes depending, in their initial stages, on photographic methods. These, however, have arrived at such importance at the present day as to exclude their consideration from the general subject, and they must be sought under their respective heads. See PHOTOLITHOGRAPHY; PHOTO-ENGRAVING; PHOTO-MECHANICAL PRINTING; PHOTO-RELIEF, etc.

In a dictionary devoted to mechanical devices and processes, it would be out of place to expatiate at length on chemical phenomena incidental to the use of apparatus. Purely theoretical considerations, therefore, connected with photography have been ignored in the foregoing article, and the labors of Sir John Herschel, Robert Hunt, and others, in the early days of photography, and of such men as G. Wharton Simpson, Hermann Vagel, and M. Carey Lea, have not been given the prominence they deserve and should have had in an exhaustive treatise.

Without, however, going into theory, the attention of the reader seeking general information should be directed to the marked differences which manifest themselves in the nature of the sensitiveness of chemical compounds. In one class, the actinic rays have power to effect at once a complete change. This is true of the mixture of chlorine and hydrogen; of the bichromates in the presence of organic matter; of asphaltum; and of chloride of silver, when substances are present (as free nitrate) capable of combining with the liberated chlorine.

To a second class belong the iodide and bromide of silver. The action of light upon them appears to be a sort of polarization, for want of a better word; an incipient molecular change, by virtue of which the particles affected are enabled to determine and accelerate the precipitation of certain bodies (metallic silver and metallic mercury) when offered in an extremely

divided state, and to do this with an energy proportional to the intensity of the luminous action or its duration. The daguerreotype and the negative-collodion process illustrate this phenomenon. The production of the picture in both cases is by true *development*, — a term often used, but not applicable in its proper and restricted sense to the bringing out of the picture after the exposure of an asphaltum surface, or of a piece of sensitized carbon tissue. A simple solvent acts in both these cases as the agent for *removing* the unaffected parts. (*Contributed to this work by* Mr. J. W. Osborne, *late of Melbourne, Australia, and now of Washington, D. C.*)

The first daguerreotype portrait from life was taken by Professor John W. Draper, in 1839. An announcement was made of it in the "London and Edinburgh Philosophical Magazine," in March, 1840. A full account of the operation was subsequently published in the same journal. The first daguerreotype view taken in America was by Professor John W. Draper, and was a view of the Church of the Messiah, taken from a window of the New York City University. Professor Morse learned the art in Professor Draper's laboratory.

Daguerre made an unsuccessful attempt to photograph the moon. Dr. J. W. Draper of New York succeeded, in 1840, in obtaining a photograph of the moon on silver plates with a telescope of five inches aperture. He presented specimens to the New York Lyceum of Natural History in 1840. Professor G. P. Bond of Cambridge, United States, made photographs of the moon, in 1850, with the Cambridge refractor of fifteen inches aperture. Many others followed. Mr. Rutherford's photographs of the moon are most excellent. Mr. De la Rue, in England, must also be mentioned.

Mr. Rutherford of New York City has been, for some time, photographing groups of stars, by which their positions are exactly recorded, without the error of personal equation. The groups of stars are photographed twice a year, six months apart. The telescope takes directly a field of about two degrees. Some of the groups contain as many as 125 stars, down to the ninth magnitude, taken upon a plate 5½ inches square. A star suspected of proper motion is placed in the center of the plate. The plate is exposed six minutes, and then the teleseope is moved slightly, relatively to the object, by stopping the clock. The plate is then exposed six minutes longer, duplicating all the stars upon the same plate, so as to identify them from other spots upon the plate, and verify their positions. With the micrometer, each star is determined in position by its distance from the central star, and by the angle of the line from it to the central star with the east and west line. In order to get rid of any constant error from the direction of the telescope, stars are taken first on one side of the pier and then, when the stars are in a different position, with the telescope upon the other side of the pier. By repeating the groups six months apart, he hopes, by and by, to ascertain the amount of parallax of some of them. An absolute map of these groups for future use is thus obtained. See under the following heads: —

Actinometer.
Albertype.
Albumentype.
Ambrotype.
Amphitype.
Asphaltotype.
Aurotype.
Authotype.
Autotype.
Calotype.
Cameotype.
Camera.
Carbon-printing.
Catalysotype.
Chemitype.
Chromatype.
Chronotype.
Chrisotype.
Chrystallotype.
Collodio-chloride process.
Collodiotype
Crossed lens.
Cyanotype.
Daguerreotype.
Developing
Diaphanoscope.
Diaphanotype.
Diaphragm.
Dipper.
Duplex type.
Dynactinometer.
Elliotype.
Emolliotype.
Enameled photograph.
Energiotype.
Etching.
Ferrotype.
Fixing.
Fluorotype.
Focimeter.
Focusing-glass.
Foxtype.
Fuming-box.
Gaudinotype.
Gilding.
Graphotype.
Gumming.
Hallotype
Heliochromatype.
Heliochrome.
Heliograph.
Heliographic engraving.
Heliotype.
Hellenotype.
Hillotype.
Hyalotype.
Ink-printing process.
Intensifying.
Ivorytype.
Kit.
Lampratype.
Leggotype.
Leveling-stand.
Lithotype.
Melanotype.
Negative.
Negative-bath.
Opalotype.
Panotype.
Photo-electrotype.
Photo-engraving.
Photo-galvanograph.
Photo-gelatine printing-process.
Photogenic drawing.
Photoglyphic engraving.
Photoglyptic engraving.
Photograph-enamel.
Photographic camera.
Photographic camera-staud.
Photographic chair.
Photographic cutter.
Photographic engraving.
Photographic head-rest.
Photographic lens.
Photographic micrometer.
Photographic printing.
Photographhometer.
Photography.
Photoheliograph.
Photoheliotype.
Photohyalotype.
Photo-intaglio engraving.
Photolithography.
Photo-mechanical printing.
Photo-metallography.
Photometer.
Photo-micography.
Photo-processes.
Photo-relief engraving.
Photoscope.
Photosculpture.
Phototype.
Photo-vitrotype.
Photozincography.
Plate-holder
Porcelain picture.
Positive.
Pressure-frame.
Print-holder.
Printing.
Printing-frame.
Retouching-table.
Screen.
Sennotype.
Sensitizing.
Silver-printing.
Sphercotype.
Talbotype.
Tent.
Tithonotype.
Toning.
Varnishing.
Vignetter.
Vitrotype.

Pho'to-he'li-o-graph. An instrument made for the British government by Dallmeyer of England, for observing transits of Venus. It consists of a telescope, mounted for photography, about eight feet in length, and having an object-glass of four inches in diameter and five feet focal length. At the focus is placed an instantaneous shutter which serves to expose and immediately close an aperture, behind which is placed a combination of lenses, corrected for the chemical rays. The image passing through is enlarged to four inches. The instrument is mounted on an equatorial stand and actuated by suitable clock-work. A similar instrument was used by De la Rue at Kew.

Pho'to-hy-al'o-type. See Hyalotype.

Pho'to-in-tagl'io En-grav'ing. A process in which, by photographic means, lines are etched in a plate to be subsequently filled with ink and printed by the copperplate printing-press.

In 1827, following in the footsteps of his uncle, Niepce de St. Victor laid an asphate ground upon a metallic plate, which probably granulated as the menstruum evaporated. This was exposed under a positive, the unaltered asphaltum removed by essence of lavender, and the plate etched with acid. This was analogous to the process disclosed by the elder Niepce to Daguerre when their copartnership was formed, for the purpose of perfecting the sun-pictures to which the name of daguerreotype was subsequently applied. It is tolerably certain that the elder Niepce had not merely the intention of making pictures, but designed to use the process for the production of intaglio etchings. This intention seems to have been lost sight of in the wonderful successes of Daguerre's process. A specimen of his photographic engraving effort is said to be in the possession of the French Photographic Society, and several of his asphate photographs upon metallic plates are in the British Museum.

In the photo-engraving process of Fox Talbot, in 1852, he prepared a metallic plate with a thin coating of bichromated gelatine exposed under a transparent positive, and etched the plate with a solution of bichloride of platinum or perchloride of iron in water. The unaltered portions of the gelatine being pervious to the etching liquid, the plate was dissolved away, while the altered portions, being impervious to water, protected the plate below them. The etching liquid, which corrodes the plate, penetrates the unaltered gelatine, but does not evolve gas, and consequently does not disturb the film of gelatine. He endeavored to obtain half-tones by the interpositiou of crape, etc. He termed it Photoglyptic Engraving.

Paul Pretsch of Vienna, working in London, about 1854, established the photo-galvanographic company in that city. His method consisted in preparing a layer of bichromated gelatine of appreciable thickness, which, after exposure under a *cliché*, was immersed in water and allowed to swell. The gelatine by this treatment produced a number of reticulations, which, in their size and nearness, were somewhat proportionate to the actinic activity of the light. This made a kind of grain, which was copied by electro-deposition, forming an intaglio printing surface which held the ink in its fine lines. He subsequently applied the same principle to the production of relief plates, for which he obtained an English patent, about 1855. He was probably the only man who ever attempted to obtain by photographic means a relief plate for the type-press direct from nature. See Photogalvanograph.

Duncas Dallas, about 1862, is believed to have operated in substantially the same way, but with better success.

Egloffstein, in New York, worked a process based upon the Fox Talbot method. Eidlitz established the Phototype Company of New York, and his efforts were nearly identical with Pretsch, excepting, perhaps, that he successfully threw down a deposit of copper on the swelled and still moist gelatine.

Pho'to-li-thog'ra-phy. A mode of producing

by photographic means designs upon stone, from which impressions may be obtained in the ordinary lithographic press.

Indications of efforts in this direction may be credited to the late Joseph Dixon of Jersey City, and to Lewis of Duhlin, about 1841. Dixon's attempt was analogous to Poitevin's process, as described hereafter, and Lewis's was an ingenious modification of the daguerreotype process, in which a thin surface of silver applied to an underlying resinous coating was so treated subsequent to the photographic image being produced thereon, by exposure to light and mercurial fumes, as to lay bare portions of the greasy or resinous matter, which was then susceptible of transfer. No specimens or contemporaneous description by either method is known to be extant. The following embrace all the typical photolithographic processes at present known: —

1. Lemercier, Barreswil, and Lerebours of Paris patented in France, July 3, 1852, a method which consisted in an application to stone of Nicephore Niepce's very early experiments to produce a photographic image on metallic plates. They dissolved asphaltum in ether, and coated the clean stone with a thin varnish of the same. By exposing such a surface under a negative the bitumen undergoes a slow change, becoming insoluble in the parts exposed to light. A subsequent washing with ether removes the unchanged soluble portions, leaving the picture visible upon the stone, which is then to be gummed, rolled up, etched, and printed. (See LITHOGRAPHY.) This process preceded that of Macpherson of Rome (October 14, 1852) by only a few months; five years later the Imperial printing-office in Vienna experimented in the same direction. See HELIOTYPE.

2. Poitevin, of Paris, patented in England, December, 1855, a process for producing pictures on stone, based upon Mungo Ponton's discovery, that a sheet of paper saturated with a solution of bichromate of potash and dried, was sensitive to light. Ponton, without ignoring the possible action of the substance of the paper, believed this liability to change to be inherent in the salt itself, but Becquerel subsequently explained its true nature as depending on the organic character of the sizing employed, which was apparently affected by the chromic acid set free by the action of light. It remained, however, for Poitevin to discover and make application of the great fact that organic matter so changed repels water and has an affinity for grease, resembling in this respect the behavior of a lithographic drawing on stone. Joseph Dixon, above referred to, published this fact in 1854, and therefore deserves the credit of priority; but the description he gives of his experiment, and the suggestions made by him, though embracing much of what was afterward elaborated by Poitevin, are hardly sufficient to displace the latter as the inventor of a typical process.

According to Poitevin's description of his process, he coated a lithographic stone with a mixture of albumen, gelatine, gum, or similar organic matter (really selecting albumen), and bichromate of potash. He then dried the surface and exposed it under a negative. He then damped the stone, rolled up with lithographic ink, etched, and printed. It may be here remarked that Dixon's experiment contained the gist, though unperceived by any, of the recent important inventions of Tessié du Motay, Albert, Edwards, and others, inasmuch as he really printed from an organic deposit which lay between the ink and the stone. See PHOTO-MECHANICAL PRINTING; CARBON-PRINT; GELATINE PROCESS; HELIOTYPE.

3. Cutting and Bradford, Boston, Mass., patented a process in England, February 23, 1858, and in the United States, March 16, 1858, which consisted in coating a stone with a solution of gum and bichromate of potash, with an addition of sugar; drying the same and exposing under a transparent positive. After the actinic change was effected they washed the stone with soap-water, which penetrated only the parts unchanged by light, and formed there the lithographic picture susceptible of taking ink. The stone was then treated according to the usual lithographic methods, including probably its etching and gumming.

4. Asser of Amsterdam patented in France, in 1859, the first transfer process. He prepared a sheet of unsized paper or of paper slightly sized with starch, with a solution of bichromate of potash, dried it in the dark, exposed it under a negative, and then washed it thoroughly and dried it. This sheet was now subjected to a high temperature on a metallic plate, then again damped as a lithographic stone would be damped for printing, and rolled up with transfer-ink. The parts affected by light took the ink, in quantity more or less perfectly in proportion to the actinic action. The sheet was then dried and transferred, whereby a delineation on stone was produced. This was rolled up and etched in the usual manner. This was the first transfer-process, but did not prove of practical value.

5. J. W. Osborne patented in Australia, September 1, 1859, and in the United States, June 25. 1861, a transfer-process, in which he prepares a sheet of paper by coating one side with a mixture of albumen, gelatine, and bichromate of potash, and dries it in the dark. This is exposed under a negative, whereby a visible change is produced, the brilliant yellow of the sheet, due to the salt of chromium, being changed to a chestnut-brown. In addition to this visible change, the organic matter becomes insoluble. A coating of transfer-ink is now applied to the whole exposed surface, by passing the sheet through the press face down upon an inked stone. When the sheet is removed the photographic picture is almost invisible. The sheet is then floated, ink side upward, upon hot water, the action of which is to coagulate the albumen, rendering it insoluble, and to swell and gelatinize the gelatine, causing the part affected by light to appear depressed by contrast. The sheet of paper, so floated, is next placed upon a slab, and the superfluous ink rubbed off by a wet sponge. This operation develops the picture. The sheet is then washed, dried, and transferred to the stone in the usual way. The coagulated albumen forms over the whole surface of the paper a continuous film which adheres strongly to the stone during the transfer-process, preventing any shifting and consequent doubling of the lines. This is, for all practical purposes, the first successful photolithographic process, and has been used in the Crown-Lands Survey Office of Victoria since September, 1859, in the publication of maps. Substantially the same process is used in the Ordnance Survey Office of England. The duplication and copying of drawings for the United States Patent Office has been for some years performed by Osborne's process, and in accuracy and speed leaves nothing to be desired.

6. Hannaford of London, in August, 1861, suggested a transfer-process, which he never put in practice, but the essential features of which were subsequently patented in England by Toovey in 1864. A sheet of paper was to be prepared by a solution of gum and bichromate of potash, exposed under a negative, and then transferred damp to a stone, without previous inking. The gum passed over to the stone on all portions corresponding to the opaque parts of the negative, and as explained in the lithographic process, incapacitated the stone at such parts for the reception of ink. On the removal of the sheet, the application of the roller brought up the picture, which was then etched and printed.

Direct processes upon the prepared surfaces of stone are not now used, all successful photolithographic work being dependent upon the transfer-process. See LITHOGRAPHY.

Pho'to-me-chan'i-cal Print'ing.

A general term embracing all photo-processes in which a printing surface is obtained without the intervention of hand-engraving. (See PHOTO-ENGRAVING.) The processes are very various, and the results obtained are of several kinds.

1. The *surface* printing, allied to the *lithographic*, includes *albertype*, *photolithography*, *photozincography*. See, also, AUTOTYPE; CARBON-PRINTING; GELATINE PROCESS; HELIOTYPE.

2. The *relief-printing* produces plates which may be printed like type, and includes *photogalvanography*, *phototype*.

3. The *intaglio* printing includes the *photoglyptic* process.

4. See WOODBURY PROCESS.

A succinct statement of gelatine and similar organic matter associated with bichromate of potash in photo-mechanical processes may be given as follows: —

1. Mungo Ponton, 1839, first discovered the sensitiveness to light of a sheet of paper treated with bichromate.

2. Becquerel, 1840, determined that the sizing of the paper played an important part in the change.

3. Fox Talbot, 1853, discovered and utilized the insolubility of gelatine exposed to light in the presence of bichromate.

4. Paul Pretsch, 1854, discovered and utilized the quality which such exposed gelatine possesses of not swelling in water.

5. Joseph Dixon, 1854, was the first to use organic matter and bichromate upon stone to produce a photolithograph.

6. Poitevin, 1855, was the first to recognize the fact that bichromated organic matter altered by light took the greasy ink from the roller.

7. Tessié du Motay and Marechal, 1864, were the first to print from a photographic image on bichromated gelatine as from a lithographic stone.

Pho'to-me-tal'lo-graph. See PHOTOZINCOGRAPH.

Pho-tom'e-ter. An instrument for measuring the intensity of light. They are of several kinds.

1. For comparing with the solar light by allowing a small graduated portion only of the solar disk to be seen. — HUYGHENS.

2. By the interposition of dimmed glasses. — RUMFORD.

3. By a comparison of distances at which small circles on white paper are visible. — CELSIUS.

4. By a comparison of the proportionate force of two different lights. — RUMFORD, BOUGUER, and LAMBERT.

a. *Ritchie's* box with reflectors and two parallel images.

b. *Deslaurier's* parallel lamps and images.

c. *Bunsen's* reflecting and transmitting screen; an opaque margin and translucent center, lights being on opposite sides.

d. A modification in which the screen is translucent with a still more transparent central disk.

5. By a comparison of shadows. — PRIESTLEY.

6. By polarization. — ARAGO.

7. By a differential thermometer — LESLIE.

8. By a comparison of illuminated images. — WHEATSTONE.

The photometer is used for measuring the illuminating power of gas. The standard of gas varies according to statute, or, in some places, custom. Some gas corporations have no apparent standard, and drive anything through the mains which will turn the meter and not poison the people too rapidly.

The standard of the London gas companies (and this is understood to be professedly the same with the Metropolitan Gas Company, of New York) is that the gas when burned at the rate of five cubic feet per hour shall give a light equal to the

burning of fourteen spermaceti candles, each consuming 120 grains in the same time.

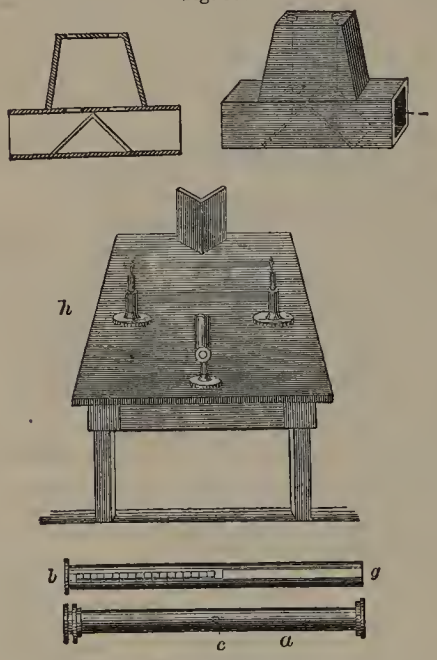
1. Huygheus, in making a relative estimate of the comparative intensities of the sunlight and that of Sirius, employed a tube having a very small aperture at one end, into which was inserted a minute globular lens, which allowed only $^1/_{27664}$th part of the solar disk to be seen. He found that this small portion afforded a light equal to that of the star, and therefrom concluded that the star was 27,664 times more distant than the sun; a conclusion from arbitrary premises.

2. One *photometer* of Count Rumford consisted of a number of pieces of dimmed glass, which were placed in succession in front of the light until the light was no longer visible. The relative intensity was determined by the number of pieces required to make the light disappear.

Fig. 3682 shows a tube *a* inclosing an inner sliding tube *b*, one half of which is graduated and the other has an opening for the insertion of a slip of glass *g*, photographically graduated in color from transparency to total blackness.

The outer tube is held so that the aperture *c* is presented to the light, which passes through the slip *g* and is reflected to the

Fig. 3682.



Photometers.

eye end of the tube by the mirror within it. The distance which the tube must be drawn out to render the light visible measures its intensity and is indicated by the graduations.

3. The photometer of Celsius consisted in observing the greatest distance from the eye, on which small circles painted on paper were distinctly visible in different lights.

4. Count Rumford, Priestley, Bouguer, and Lambert all gave their attention to this subject and elicited the following principle: —

Though the eye cannot judge of the proportionate force of different lights, it can distinguish with considerable precision when two similar surfaces presented together are equally illuminated, or when the shadows of an opaque object thrown upon them by different lights are equally dark.

Ritchie's apparatus is founded upon the former idea (Bouguer's); the lights to be compared being separately received by mirrors set at an angle of 45° in a box with a blackened interior surface and reflected therefrom to adjacent disks of oiled paper so that their comparative luminosity may be compared. When one excels the other it is retreated until an equality of luminous effect is established. The values are then as the squares of the distances from the reflectors.

Bouguer's photometer (upper figure) is substantially similar, the rays of the luminous objects to be compared being directed into two funnels and impinging upon two disks of uniform translucency. The comparison is made as in the former case. The views are respectively a section and an elevation.

h is a simple apparatus on the same principle, formed by simply bending a card. The lights to be compared are placed so that each shall be reflected from a single face of the card, so as not to interfere with the other. The reflections are viewed through a tube placed on the prolongation of the line bisecting the angle of the faces.

Another form of the *light* comparison is adopted in some gasworks where the lights to be compared are thrown upon opposite sides of a screen interposed.

This is Bunsen's photometer, which depends for its action upon the combination of reflected and transmitted light.

"The rays from the two lights to be compared are received on the opposite sides of a screen, one part of which is white and nearly opaque and the other part translucent. When the rays of a single flame only strike against one side of the screen, those portions through which the light passes seem dark and the opaque parts bright. But the opposite effect is produced when viewed from the back of the screen, for then the opaque part seems dark and the translucent part light. On lighting another flame on the opposite side of the screen, the dark part is illuminated while the light passes through the other portion and adds but little to its brightness. Thus, the part that is bright on one side is dark on the other, and the converse. If the light on each side of the screen be equally powerful, the dark part will nearly disappear, for the reflected and transmitted lights combine to illuminate both surfaces equally. This effect is produced by shifting the screen toward the feeble light, and by squaring the distance from each the relative illuminating power of the two is ascertained." — Clegg.

5. The form of photometer founded upon the comparison of shadows has been ascribed to Count Rumford and to Dr. Priestley. The latter describes it as follows: —

"When two lights of varying intensity shine upon the same surface at equal obliquities, and an opaque body is interposed, the two shadows produced differ in blackness or intensity in a similar degree." The shadow produced by intercepting the greater light, being illumined by the lesser only, the other shadow would be less intense and the strongest light would have the deepest shadow. Thus, when two lights are to be compared, they should be so placed that a ray from each should fall with the same angle of incidence upon the middle of a sheet of paper; by interposing some opaque object the two shadows it occasions may be made to lap over each other; then, if the lights are removed from or brought nearer the paper, until all the shadows are of the same intensity, it will be found that the amount of light emitted by each will be as the squares of the distances from the paper.

6. Arago's photometer is founded on the properties of polarized light

"When two lights are to be compared, the rays from each are polarized by causing them to pass through a plate of tourmaline cut parallel to the axis, or by reflecting them from a plate of glass on which they fall at the polarizing angle. They are then received on a plate of rock crystal, cut perpendicularly to the axis, and observed through a doubly refracting prism. Each light will thus give two images tinged with the complementary colors. The images are then brought into such a position that the red of one falls over the green of the other. If the two lights be equal in intensity, this superposition will produce a white image; if unequal, the image will be slightly colored with red or green, according as the one or the other predominates" — Brande.

This ingenious contrivance has been rather a curiosity than a practical apparatus, as it is complicated, and requires considerable trouble in the manipulation.

7. Leslie's photometer is constructed on the assumed principle that light is convertible into heat. The differential thermometer with a black and a clear bulb is placed under a case and successively exposed to the lights under experiment, the rise of the thermometer being observed.

8. Wheatstone's photometer has a small convex reflector, which affords bright images of the two lights under comparison. By causing the bead to traverse, two parallel lines of light are formed and the comparison rendered more easy. The lights are adjusted as to distance till the images have equal luminosity.

A substitute for the photometer has been proposed in the bromine test, which removes from gas the vapors upon which its luminosity depends. See "Ure," Vol. I. p. 439, American edition.

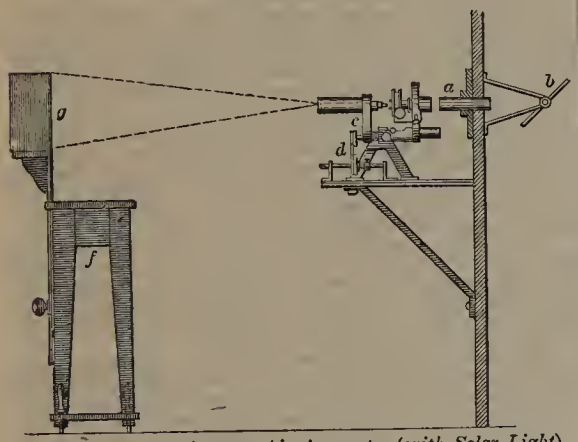
Pho'to-mi-cog'ra-phy. At the time when photography began to attract attention, efforts were made by Donné to depict microscopic objects by the Daguerrean process, which did not, however, yield satisfactory results. The new process of photography, however, in the hands of such experimenters as Professor Gerlach of Erlangen, Albert of Munich, and Dr. R. L. Maddox of Southampton, was more successfully employed for this purpose. In America, the chief experimenters have been Professor O. N. Rood of Columbia College, Mr. Lewis N. Rutherford of New York, and Colonel J. J. Woodward of the United States Army Medical Museum. The latter has devoted much attention to the subject, and has succeeded in carrying the process to a high degree of perfection. In 1861, Professor Rood, in a paper published in "Silliman's Journal," described the process as then employed by him, by which he had succeeded in obtaining photographs of diatoms and other objects magnified from 460 to 1,300 diameters, using

direct sunlight and employing ordinary achromatic objectives with or without eye-pieces.

Mr. Rutherford, in experiments on stellar photography, had employed an achromatic objective having its crown and flint glass lenses so combined as to give a focal length about $\frac{1}{10}$ less than that proper for vision, so as to obviate dispersion of the actinic rays and bring them accurately to a focus. He suggested the application of this principle to the microscope. Colonel Woodward, taking the subject up at this point, perseveringly experimented, bringing the process to the high state of practical perfection in which it is now employed at the Army Medical Museum. The general features of this system consist in dispensing with a camera and the non-use of ground-glass.

The operating-room has two windows, through one of which sufficient yellow light is admitted to enable the operator to work; the lower part of the other window is provided with a shutter 14 inches high, the upper part being blackened. In the shutter is a hole in which is inserted a tube *a*, through which the solar light reflected from a plane mirror *b*, or, preferably a heliostat, is thrown upon the achromatic condenser of the microscope; the microscope *c* is placed on a shelf at the window of the dark room, and the light reflected through the tube, which is provided with an achromatic lens of about 10 inches focal length, is thrown upon the achromatic condenser. *d* is the focusing device; *g f*, the negative-holder and its stand. For powers from 200 to 500, a $\frac{1}{8}$-inch objective without an eye-piece is used, the power being varied by increasing or diminishing the distance of the sensitized plate from the instrument. A cell filled with ammonio-sulphate of copper, which absorbs

Fig. 3683.



Woodward's Microphotographic Apparatus (with Solar Light).

the non-actinic rays, is interposed between the large lens and the condenser, and a hood is drawn around the instrument to prevent leakage of light into the room.

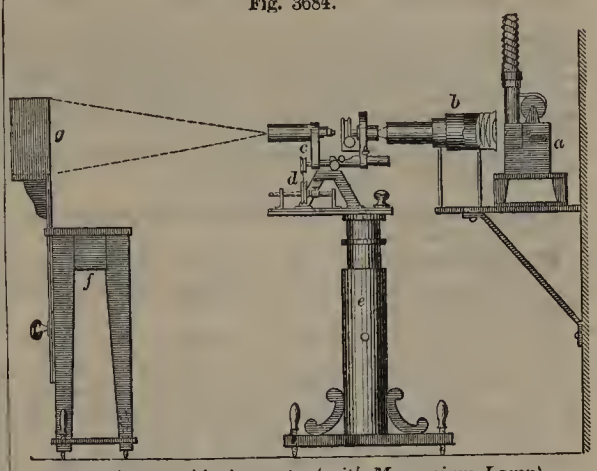
For objects magnified less than 500 diameters, the time of exposure, being less than a second, is regulated by a sliding shutter placed before a slit in front of the microscope, the width of the slit being adjusted to correspond with the required length of exposure. For powers between 500 and 1,500, a $\frac{1}{16}$-inch objective is employed, dispensing, in general, with an eye-piece or amplifier, and placing the sensitized plate at a distance not exceeding 3 to 4 feet from the microscope. In the case of objects having very minute details, however, it is frequently advantageous to employ an eye-piece or amplifier, rather than enlarge a negative taken with a smaller power.

Though natural sunlight is to be preferred, it may be sometimes necessary, when this is wanting, to employ artificial illumination; for this purpose, the electric, the magnesium, and the oxycalcium lights have been used with success. Of these, the electric light is the best, and for its production Dr. W. employs a Duboscq lamp, operated by a battery of 50 small Grove elements, 10 in a cell

The magnesium light affords an illumination similar to white-cloud light, or that of the sun after passing through ground glass, and is well adapted for photographing soft tissues with powers less than 1,000 diameters; there are no interference phenomena, but with powers exceeding 1,000 diameters the time of exposure becomes inconveniently long.

Fig. 3684 shows the arrangement employed. The magnesium lamp *a* stands on a shelf fastened to the wall; the condenser *b* concentrates the light on the achromatic condenser of the microscope *c*, which stands on a table *e* supported upon three leveling screws. The image received on the plate-holder *g* supported on the table *f* is photographed precisely as in the case of the electric light. The same focusing apparatus *d* is employed, and the ammonio-sulphate cell is invariably inserted. See Dr. Woodward's articles, "American Journal of Science and Arts," Vol. XLII. (Second Series), pp. 189–195. Also "Reports to the Surgeon-General," 1870–71.

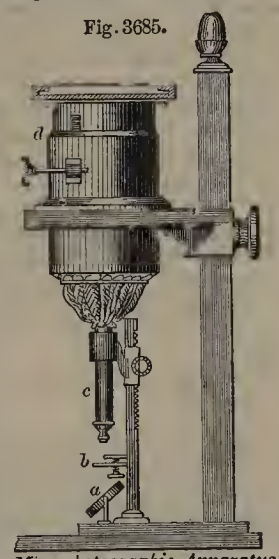
Fig. 3684.



Microphotographic Apparatus (with Magnesium Lamp).

Fig. 3685 shows a photo-micrographic apparatus from Otto Buchler's "Atelier und Apparat des Photographen" *a* represents the mirror, *b* the object-holder, *c* the microscope, and *d* the dark-chamber, on top of which is the plate-holder. The adjustments are three: one for the object-holder, one for the microscope, and a third for giving the dark-chamber the proper vertical elevation. The arrangements shown at Figs. 3683, 3684, are, however, undoubtedly preferable. See also MICROGRAPH; MICROPANTOGRAPH; NOBERT'S PLATES; MICROSCOPE.

Fig. 3685.



Microphotographic Apparatus from Buchler.

Pho'to-pro'cess-es.

PHOTO-PROCESSES.

- Photography.....
  - Calotype.
  - Daguerreotype.
  - Ambrotype.
  - Silver printing.
  - Collodion.
  - Carbon printing.
- Photo-mechanical processes.....
  - Photo-engraving
    - Photo-relief.
    - Photo-intaglio.
    - Woodburytype.
  - Photolithography; Photozincograph.
  - Photo-gelatine printing (Collography.)

Pho'to-re-lief' En-grav'ing. Properly, one in which, by photographic means and subsequent manipulations, a printing surface is obtained which stands above the general level to receive the ink and may be printed as type or woodcuts.

Paul Pretsch, November 9, 1854, prepared a surface of bichromated gelatine with other less essential chemicals, and exposed under a transparent positive. By plunging this, after exposure, into water, the unaltered gelatine swells into relief, forming a surface which may be copied by the galvanoplastic or stereotype process to form a relief-printing process. Also known as a PHOTO-GALVANOGRAPH (which see).

Poitevin, December 13, 1855, had a process substantially similar, using plaster hardened with protosulphate of iron to obtain a cast.

Osborne and Robertson, in 1860, transferred the photolitho-

graphic transfer-sheet to zinc and etched the zinc to make a relief.

Leggo, about 1866, coated the back of a transparent positive with gelatine and bichromate, allowing it to gelatinize only, not to dry, exposed from the face, and finally washed away the unaltered gelatine, leaving a number of depressions, corresponding to the positive parts of the picture. A casting was made from this in the electro-bath or by stereotype.

Woodbury's process, though called *photo-relief*, scarcely comes within the definition. See WOODBURY PROCESS.

Pho'to-scope. An instrument or apparatus for exhibiting photographs.

Pho'to-sculp'ture. M. Villème, an eminent French sculptor, is credited with the invention of this ingenious process.

The subject to be modeled stands in a circular chamber, while from 24 circular apertures in the wall provided with as many photographic apparatus 24 photographs are taken, giving that number of portraits from different points of view. By this means, the sculptor, having 24 photographs, representing the subject from as many different points of view (all taken at once), has but to turn the block of clay, after each operation, $\frac{1}{24}$ of a revolution, and then cut in correspondence to the next profile as traced by the pantograph on the clay. After the block has completed a revolution it is transformed into a solid figure of the 24 photographs.

Expedition and accuracy are secured by this means, but no doubt it would and does disgust one of the old school almost as much as taking a cast from life and using the cast as a pattern in a "pattern" lathe to turn a bust out of the marble by automatic devices and steam-power.

Pho'to-type. (*Photography.*) A general term for processes in which sun-pictures, or *light-pictures*, as the name indicates, are made printing-surfaces and thus become the means of multiplying pictures.

The term has been specially applied to the following process: —

An impression on a plate in raised characters derived from a transfer obtained by the photozincographic process. The original manuscript or page of type is photographed, treated with ink, washed and transferred to the plate, which is then *bit in*, so as to depress the surface at points not protected by the ink. (See PHOTOZINCOGRAPHY.) For an analogous process, see PHOTOGLYPHIC ENGRAVING. The resulting plate has a salient impression, and is printed from as with ordinary type.

Pho'to-vit'ro-type. (*Photography.*) A light picture printed on glass.

Pho'to-zin-cog'ra-phy. A process for the production of delineations on zinc by the aid of light, from which impressions can be printed after the manner of zincography. This method of producing and printing facsimiles is identical with photolithography, save in the fact that zinc plates are substituted for stone.

Cutting and Bradford, as well as Osborne, contemplated the production of the printable picture on zinc, as well as on stone; the latter produced copies of maps in this way in March, 1860. To Col. Sir Henry James, however, the credit is due of giving to a process on zinc, elaborated by the employees of the Southampton Map Office, considerable prominence and importance. This process resembles Asser's, but only to the extent that a transfer is employed. In its details it is identical with Osborne's (omitting the use of albumen). Both these inventors anticipated James, and published elaborate descriptions of their processes.

The Southampton office has made a very useful application of photozincography for the production of old historical manuscripts, such as "Domesday Book" and similar documents; but the quality of the results obtained does not appear to have reached a degree of excellence which would justify the extended application of the process to the production of maps.

The only advantage which photozincography possesses over the analogous processes on stone is the lightness and cheapness of the plates. See LITHOGRAPHY; PHOTOLITHOGRAPHY; and ZINCOGRAPHY.

Phthon-gom'e-ter. A measurer of vowel quantity. (WHEWELL.) He refers to Kempelen's and Willis's talking-machines, in which acoustic sounds were made to assume "articulate differences," "exhibiting the relation among the vowels."

Phys'e-ter. A filtering-machine consisting of a tub, with a perforated platform about half-way up. The air is withdrawn from the lower portion, and the pressure of the atmosphere forces the liquid through the partition. See PRESSURE-FILTER.

Pi-a'no-for'te. (*Music.*) An instrument with a key-board and metallic strings put in motion by hammers. Its usual compass is about seven octaves. Its music is written on two different clefs at once, the F clef for the left hand, the G clef for the right hand.

Its strings are stretched upon a harp-shaped frame, and are struck by hammers moved by keys. The strings are of graduated length, thickness, and tension; are stretched over bridges, and fastened at their respective ends to pegs and tuning-pins, and are arranged, two or three to a note, in a plane parallel to the sounding-board, by which their sonorous vibrations are propagated and enhanced. It is distinguished from its predecessors in the same class by having a hammer to strike the string; the hammer being moved through the intervention of a jack, and retiring from the string immediately after delivering its blow.

"The piano is now, beyond all question, the first of musical instruments, both to the profession and to the cultivated classes of society." — THALBERG.

Another might say the organ, so far as power and capacity and variety of expression are concerned.

In tracing the rise and progress of the instrument whose qualities warrant such exalted praise, we shall have to go back to the primitive stringed instruments which had a few strings, representing as many notes and tuned in unison or harmony, as the case may be, with a degree of skill depending upon the ear and attainments of the performer.

We may fairly suppose that the first instrument of this kind was played by the fingers. In process of time, as it was discovered that either thickness, length, or tension would effect the object of a difference of tone, the frame would assume a somewhat triangular shape, the longer strings being the nearest to one side, to which all the strings were parallel.

We have then arrived at the *harp*, which must have been used for ages before it attained the splendid proportions and finished appearance of those found represented in a tomb of the time of Rameses III., 1235 B.C. These figures are called *Bruce's harpers*, from their discoverer, and are illustrated under the section treating of that instrument. See HARP.

The Old Testament Scriptures abound in the names of instruments of the harp kind; the *lyre*, the *psaltery*, and instruments of 10 strings. The Egyptian harps had from 4 to 14 strings as long ago as Amosis, about 1570 B.C., 900 years before Terpander.

The form of the harp-frame, as we have seen, arose from the mode of varying the tone by giving different lengths to the strings, which were of catgut or tendons; to this was added another variation by the thickness of strings. At a very early age, still another mode of varying the tone was discovered; this was by pressing on the string, and thus temporarily shortening it, raising the tone.

We have thus arrived at the guitar, which was common in Egypt. We find it represented on the temple and sepulchral paintings of Thebes, on the obelisk brought from Egypt by Augustus, and which was placed on Guglia Rotta at Rome; also on the sculptures of Nimroud. These guitars had necks, but no frets. The *guitar* is in name and fact closely allied to the harp, its Greek name *kithara* being the original of the word *guitar*, and meaning an instrument of the harp kind. See GUITAR.

The *'ood* of the modern Arabs is much like the ancient Egyptian guitar: a neck without frets, a hollow oval body, and perforated sounding-board The tuning-pins of the Egyptian instrument are clearly shown on the obelisk imported by Augustus and upset by the Constable Bourbon in 1527.

After the *harp* and its congeners, the *guitar* kind, whose strings were vibrated by the fingers and thumb, or by a *plectrum*, we find the stringed instruments diverging in two directions, a device being employed in each case to vibrate the strings. We regard the *plectrum* as being, in the main, merely a mode of saving the fingers.

The two devices referred to, which characterize separate families of stringed musical instruments, are the *bow* and the *hammer*. Of the first, we have the *violin* series: *viola*, *violin*, *violoncello*, *violone*, or *double-bass*. Of the *hammer* series, we have the *dulcimer*, *virginal*, *clavichord*, *hammer-harpsichord*, and, lastly, the supreme *piano-forte*.

Of the *bow* series, the instruments have necks and the strings

are capable of sounding various notes by being stopped to vary their lengths.

Of the *hammer* series, the strings, like those of the *harp*, express but one note each, and are numerous accordingly. The harp was, for convenience, laid prostrate, but retained its shape as it does practically to the present day.

We shall have to notice two variations presently: one in the *substitution of quill-jacks for the hammer*, the other in *uprighting the harp-frame*, as in the upright piano

The *bow series* divaricates from our present subject, and we dismiss it.

First of the hammer series, we notice the *dulcimer*. This has a series of strings tuned to the chromatic scale, and having a compass of two or more octaves. The strings are stretched over a bridge at each end of the box-cover, which forms the sounding-board. The *hammers* are pellets of cork on the ends of elastic rods held in the hands of the performer. This may be the *psaltery* of the Hebrews: it is hard to tell.

The *citole*, or little chest, was a box with stretched strings which were played by the fingers.

Now for a long step: The first stringed instrument in which the hammers were mechanically operated seems to have been the *clavicytherium*, or keyed cithara (*clavis*, a key). (See consecutive statement accompanying Plate XL, page 1692.) In this illustration of the sequence of instruments are also shown the *clavichord* or *monochord* and the *virginal*, all of which preceded the *spinet*, *harpsichord*, *hammer-harpsichord*, and *forte-piano*, as it was first named. Keys were applied to organs in the eleventh century; centuries before they were used on stringed instruments by Guido, of Arezzo, who originated the *clavicytherium*, or *keyed cithara*.

The history of the piano-forte, as we have seen, involves the early history of stringed instruments, as the piano is but a prostrate harp with strings in groups and struck by keys.

Plate XL. shows the series of improvements, beginning with the *lyre*, the invention of which is credited to Hermes (Mercury)

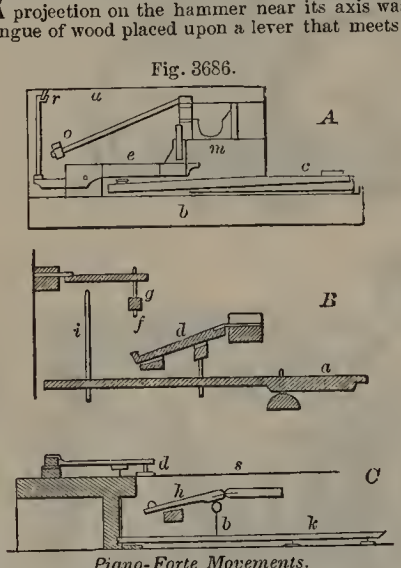
Fig. *a* is from an Egyptian tomb at Beni Hassan, the painting being supposed to represent the arrival of Joseph's family in Egypt, the tomb being contemporary with that event. *b* is from a lyre in the Berlin Museum, which is perfect except as to its strings. *c* is a drawing from a painting in Thebes, showing the use of the invention. *d* is a square lyre from a painting in Herculaneum, the figure holding a plectrum. *e* is a bow-shaped twelve-stringed *harp*, from an Egyptian painting copied by Wilkinson. *f* is from an Egyptian picture representing a figure playing on a harp with triangular frame and perpendicular strings. (See HARP, for cut of Bruce's harpers.) *g* is a medieval *cithara*. *h* is a *psalterium*, from an illuminated MS. of the fourteenth century. *i* is a *dulcimer*, from the "Musurgia seu Praxis Musicæ," by Ottomarus Luscinius, Strasburg, 1536. The dulcimer of old Assyria had strings of varying lengths passing over the sounding-board, and was slung by a strap in front of the performer while marching. It was played by a plectrum. It is known as the *kanoon* by the Arabs and Persians, who twang the lamb's-gut strings with small plectra, one attached to the forefinger of each hand. The dulcimer played with mallets is used in rural fêtes on the Continent of Europe, and known as a *hackbret* (*hackboard*, or chopping-board, the shape of which it resembles); *sackbut*, in our translation of Daniel. *j*, a *citole*, from a drawing preserved in the British Museum.

> "A *citole* in hire right hand hadde she."
>
> CHAUCER.

k, a *clavicytherium*, or keyed *cithara*, which had quilled plectra attached to the keys; the strings were of catgut. The illustration is from the "Musurgia," just cited. The *clavichord*, also known as the *monochord*, was a square instrument, and had keys on which were vertical pieces of brass pin-wire which could be pressed against the strings, which were also of brass. These pins, therefore, formed wrest-pins for the strings, which vibrated only while the key was held down, a close damper being fixed behind which acted upon the string when quitted by the pin, the key, in fact, forming one of two bridges, between which the strings vibrated. This instrument played an important part in the history of music for six hundred years. It was Bach's favorite instrument; it formed part of Mozart's traveling equipment. It is said by Blount ("Glossographia," 1656) to be so named "because the strings are wrested up with a *clavis*, a key." *l* is the *clavicymbal*, in which the strings are disposed harp fashion. Its strings are of steel wire, sounded by quill plectra on the keys. The illustration is from the "Musurgia." *m* is the *manichorde*, from a drawing by Mersennus, 1636. It was a superior form of *clavichord*, with 49 or 50 keys and 70 strings, which rested on 5 bridges, some of the strings being in unison. It had a hammer of brass and a cloth damper to stop the vibration after the note had been struck. It was long and narrow, and the sounding-board took up half the length of the instrument. *n* is a *virginal*, taken from a stained-glass window of the Elizabethan period. It had strings of various lengths, one to each note, of iron or steel. The strings were struck by small pieces of quill affixed to minute springs adjusted in the upper part of the jacks, which were planted in the keys and directed perpendicularly upon the strings. The name is derived from the instrument being deemed suitable for girls, or from its being used in accompanying hymns to the Virgin. *o* is a triangular *virginal* from the "Syntagma Musicum" of Prætorius. The instrument is frequently mentioned in works and inventories of the fifteenth and sixteenth centuries. Shakespeare refers to it. *p* is a curious drawing of an upright virginal from a collection of pen-and-ink drawings of ancient musical instruments, executed at the latter end of the sixteenth century. The virginal of Mary Queen of Scots was of oak inlaid with cedar and elaborately ornamented with figures of warriors, ladies, and birds. The colors are yet bright. *q* is the *spinet*, named from *spina*, a thorn or quill, the tone being produced by a crow's quill inserted in the tongue of the jack. As described by Mersennus ("Harmonicorum," Paris, 1636) it had 49 strings, of which the lower 30 were made of latten (flat brass wire) and the remainder (19) of steel or iron. The note depended on the size of string and tension, there being one note for each string, and but 5 or 6 sizes of strings. The *spinet* was always triangular, and had the wires carried over a bent bridge; the strings of the *virginal* usually went direct to the screw-pegs. The illustration is from Bonanni's "Gabinetto Armonico," 4to, Rome, 1722. *r* is the *harpsichord*, which is, in fact, a large-sized *spinet*, but it differed from the latter and from the *virginal* in having two strings to a note. The illustration is from the work of Mersennus just quoted. "The action of the harpsichord was simply a key and what is called a jack, which is a piece of pear-tree with a small movable tongue of holly, through which a cutting of crow-quill was passed to touch the string when the jack was in action." (BURNEY.) Thus the mechanism of the jack was similar to that in the virginal and spinet. Hans Ruckers joined to the two strings in unison a third one of shorter and finer range tuned an octave above the others. He mounted his instruments partly with catgut strings and partly with steel wire; he added a second key-board to reach but a single wire, and extended the compass to four octaves. Pedals were introduced about the middle of the eighteenth century, to work *stops*, as they were termed (pedals were previously used on organs), — the *forte* stop, which raised the dampers; the *soft* stop, which partly stopped the vibrations of the strings; and the *buff* stop, which interposed a layer of cloth or soft buff leather between the strings and the jacks. Tarquin of Paris first substituted buff leather for the quills in 1768. Schobert had a double tier of strings with additional sounding-board. Wieglet introduced metallic tongues in 1724; Silbermann, a mechanism like the clavichord to strike the string at its midlength, by which the harmonic sounds were heard at the same time the whole string was sounded. Stein invented the *vis-a-vis*, or double harpsichord, which was played by a performer at each end. Burney refers to a transposing harpsichord of 1760: "By drawing out the keys the hammers are transferred to different strings, by which means a composition is transposed half a note, a whole note, or a flat third lower at pleasure." In 1730 Harris took an English patent for his harpsichord, "with two sets of strings, on which may be played either one unison or two; or two unisons and an octave together, and the Fortes and the Pianos," etc. Plenius, in 1741, also refers to the "forte and piano" capacity of his instrument. In 1774, the patent of Merlin described a "new-invented kind of compound harpsichord, in which, besides the jacks with quills, a set of hammers of the nature of those used in the kind of harpsichords called *piano-forte*, are introduced," etc.

The *hammer-harpsichord*, so called from the substitution of hammers for plectra, was the first *piano-forte*, and invented by Cristofori of Florence, 1711. It had a row of leather-topped hammers, which vibrated on a rod and struck the string from below. A projection on the hammer near its axis was struck by "a tongue of wood placed upon a lever that meets the key

Fig. 3686.



Piano-Forte Movements.

A, Bartolomineo Cristofori of Florence, 1711.
B, Mason, London, 1755. *C*, single action.

PLATE XL. PICTORIAL HISTORY OF THE PIANO-FORTE, *See page* 1691.

From the Lyre of Egypt, 2000 B. C., *to the Harpsichord of the* 18*th Century* A. D.

(From authentic sources.)

and that is raised by it when pressed by the key." (See Rimbault's "Piano-forte," London, 1860.) A long description by Scipioue Maffei and a cut were published in the "Giornale de' Litterati d' Italia," Venice, 1711 (Tom. V., p. 144).

In *A*, Fig. 3686: *a*, string; *b*, frame of key-board; *c*, key with a pad on the end which comes beneath the lever *e*, which has a jack or hopper to force the hammer *o* upward when the key is depressed; *m*, the hammer rail; *r*, the damper which leaves the string when the key is touched and returns when the pressure on the key is removed. The hammer is leather-faced, and is caught by a silken string.

Marius of Paris submitted four of his instruments for examination by the Academy of Sciences in 1716, calling them *clavecins à maillets*. The hammers had leathern faces, and in one the hinged hammer was impelled against the string by the key and retreated from it, although pressure on the key remained.

Schröter's claim dates in 1718. The hammer was leather-headed and moved on a pivot, and rested near its axis upon a leather-headed pin screwed into the farther end of the finger-key. When the key was struck, the hammer was thrown up against the string and then retreated, allowing the string to vibrate. A clothed hammer being made to strike the strings, the *jack* no longer acting as a hammer, but transferring the motion of the key to the hammer, making the jack a *hammer-lifter* instead of a striker.

In each of these cases the particular value of the invention was the command possessed by the player of giving a sound more or less forcible by the force of the blow on the key,—a thing scarcely possible in the spinet and harpsichord, where the string was twanged by a passing crow-quill. The ability to modulate the sound was spoken of as capacity for *forte* or *piano* effects, and the transposed words in the article in the Venetian journal (1711), quoted above, which speaks of "the *piano* and *forte*" as being heard, and also "gradations and diversity of power, as in a violoncello," refer to the same versatility of expression.

The name *forte-piano* occurs in Harris's English patent, 1740, but the instrument was a *harpsichord*.

Silbermann made two hammer-harpsichords in 1736. His instruments, called forte-pianos, were played by Bach at Frederick the Great's palace at Potsdam. Bach regarded them as too coarse, and preferred the clavichord, "which was," as Forkel says in his Life of Bach, "poor in tone, but on a small scale extremely flexible." After Silbermann came his pupil Stein, upon whose piano-fortes Mozart so loved to play (1777). Frederici, a fellow-pupil of Stein's, made the first square piano.

The farther history of the piano introduces the name of Sebastian Erard of Strasburg, who invented the *escapement*, which effected precision in the stroke of the hammer. He died in 1831. Ignace Pleyel, another noted maker of pianos in Paris, died the same year. Zumpé made large numbers in England, 1766, and following years. The movement invented by Mason, an English clergyman, about 1755, is shown at *B* (Fig. 3386). *a* is the key rocking on a round bar and kept in place by a pin; *d* is the mallet with a hinge of vellum; *f* is the string on which rests the damper *g*, except when the key is depressed, raising the pin *i* beneath the damper-lever, which has a vellum hinge. The names of Broadwood, Stodard, and Collard are familiar as English inventors and makers in succeeding years. Gieb, in 1786, invented the *grasshopper action*. In America we have Steinway and Chickering, Knabe and many others, who have made improvements in details of construction and produce instruments of a high class.

The illustration (*C*, Fig. 3386) shows what is known as the *single action*, in which the hammer *h* is hinged to a bar and is operated by the lifter *b* on the inner end of the key *k*. At the extreme end of the key is the *sticker*, which raises the damper *d* when the key is struck. As the key is restored to its normal position, the damper falls and hushes the sound of the string *s*.

The damper existed previously in the clavichord, but was not movable vertically so as to leave the string when the hammer struck.

The *piano-forte*, as such, was introduced to the English public on the stage of Covent Garden Theater in 1767. On a play-bill of that date occurs the following: —

"*For the Benefit of* Miss Brickler, *16th of May*, 1767. At the end of the first act Miss Brickler will sing a favorite song from 'Judith,' accompanied by Mr. Dibdin on a *new instrument called the piano-forte*."

From this time its success was assured, and the harpsichord, makers changed their movements, substituting *hammers* for *plectra*, *percussion* for *twanging*.

"There are three forms of the piano-forte, viz., the *grand* and the *square*, in which the strings are placed in a horizontal position, and the *upright*, in which the strings are vertical.

"The form of the *grand* piano is the same as that of the harpsichord, and was suggested by the varying length of the strings. This form is well adapted to the introduction of the best kinds of mechanism, and is always chosen for first-class instruments. Each note is produced by the simultaneous vibration of three strings; but, in order to lessen the cost of the instrument, a form of grand piano has been constructed, in which there are but two strings to each note; such are the *bi-grand* and *semi-grand*. There are also *boudoir* or *cottage grands*, which have shorter strings and occupy less room.

"The form of the *square* piano is oblong rectangular, the same as the German clavichord, and is probably the first shape in which the piano appeared. It remained an inferior instrument until the mechanism of the grand was introduced into it, thus leading to the variety called *grand-square*. It is difficult, in this instrument, to strengthen the framing sufficiently, and the oblique position of the action with respect to the strings and keyboard is also an objection; nevertheless, this form is the best substitute for the grand.

"The *upright* piano was patented by Stodart in England in 1795. It was at first a grand, set on end, raised on legs two or three feet above the floor, and struck at the lower end. This, the *upright-grand*, as it was termed, was unwieldy from its great hight, and was superseded by the *cabinet*, invented by Southwell in 1807, in which the frame was brought down to the floor and the blow given at the upper end of the strings by means of levers and long vertical rods communicating from the key to the hammer. It formed an elegant piece of furniture, and continued long in favor. Still, however, its great hight (6 feet) and length of action were unfavorable to delicacy and ease of touch. About 1812, Mr. Robert Wornum introduced an upright piano-forte, the hight of which was from 4 to 5 feet; this was the *harmonic*, a name afterward changed to *cottage*. In 1827, its hight was still farther reduced to 3½ feet from the floor, forming the *piccolo*, which has served as the model for many others of different names and about the same size."—Tomlinson.

The square piano is much more generally used than any other in this country, while in England and on the Continent the cottage form appears to meet with most favor.

The piano-forte comprises four distinct parts: the *framing* and *sounding-board;* the *stringing;* and the striking mechanism, or *action*.

The framing, having to resist the tension of all the strings, equivalent in a full-sized grand piano to a force of about 25,000 pounds, requires to be made of great strength.

It was formerly constructed solely of timber; the strings were looped at one end around studs driven into a block of wood termed the string-block, their other ends being wound around a series of iron *wrest-pins*, inserted into another piece termed the *wrest-plank*. These were separated by a trussed framing, arranged so as to resist as completely as possible the tendency of the strings to draw these two parts together. It was, however, found that, owing to the great strain, even the most seasoned timber was liable to become distorted, causing the instrument to get out of tune. This defect also precluded the use of heavier strings for the purpose of increasing the power of the instrument. As a remedy, the system in general use of combining wood and metal in the framing was invented. This was adopted in part by Broadwood in 1808, and in 1820 Stodard patented the first complete system of metallic bracing, also including a means of counteracting the expansion and contraction of the strings under varying temperatures by means of a series of tubes which expanded or contracted simultaneously with them, but in an opposite direction.

The general features of the combined framing of wood and metal, as applied to a grand piano-forte, consist in attaching the studs to which the rear ends of the strings are secured to an iron plate curved to the form of the hollow side of the instrument, and called the *string-plate*. From this metallic bars extend parallel with and above the strings to the *wrest-plank*. The bars are firmly connected at their ends to the string-plate and wrest-plank, and secured at intervals throughout their length to the timber framing below, to which the string-plate is also firmly fastened; both the bars and string-plate are usually of wrought-iron or steel. Seasoned and well-dried oak glued up in several thicknesses to insure greater permanence of form is employed for the wooden parts of the framing.

The cast-iron string-frame is credited by the English writers to Pleyel & Co. of Paris.

In order to enable the hammers to strike the wires, an opening is necessary completely across the wooden framing under the strings; this is spanned by small thin arches of metal abutting on one side against the wrest-plank and on the other against a transverse rail, called the *belly rail*, which forms a portion of the main body of the framing, taking the thrust caused by the tension of the wires. Of late years, framings entirely composed of metal have been extensively employed in the United States.

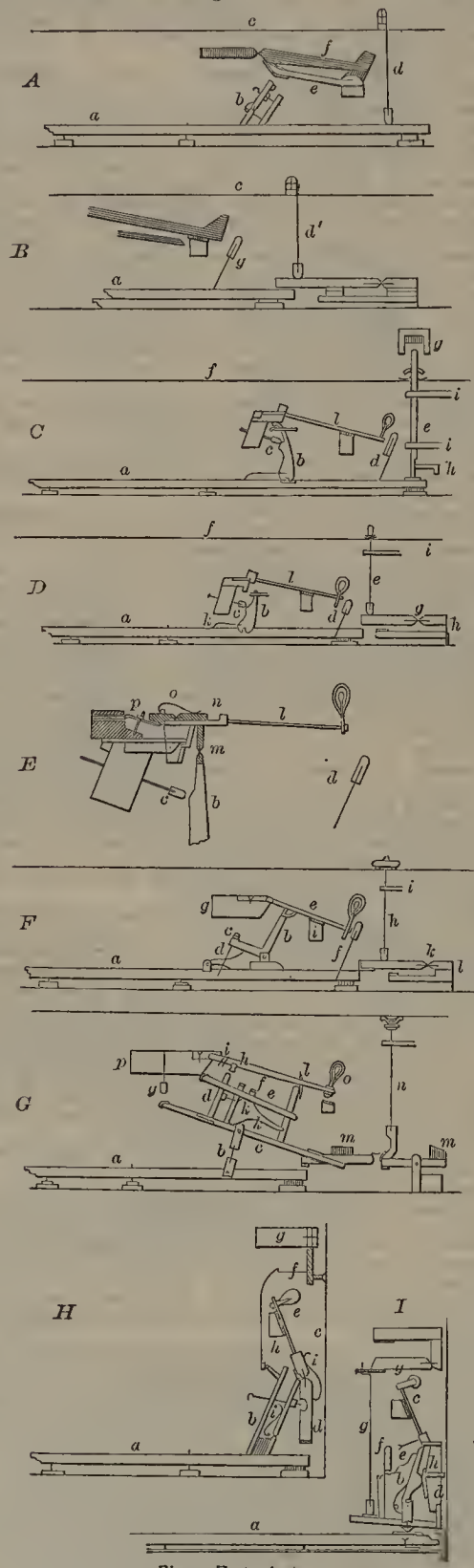
Owing to the wide and deep space required for the keys and action in square pianos, the strengthening is effected by bolting down the wrest-plank and string-plate upon a strong bed of timber extending from beneath the keys, so as to form the bottom of the instrument. One or more metallic bars above the strings also extend from the wrest-plank to the string-plate. Framings exclusively of iron are also used in this class of instruments.

The upright piano requires no aperture for enabling the hammers to strike, and its framing is, therefore, simply sustained by vertical bars at the back of the instrument, to which the wrest-plank and string-plate are attached, and which receive the force exerted by the tension of the strings in the direction of their length. Iron braces behind these are sometimes added, or they are replaced by metallic tubes.

The *sounding-board* or *belly* is a boarding of light wood about one fifth of an inch thick, occupying in a grand piano the whole area of the instrument, in a square piano about two fifths of

its length, placed below the strings, or, in upright instruments, behind them. It must be made of wood free from knots or imperfections, and cut in a particular direction of the grain. Its

Fig. 3687.



Piano-Forte Actions.

edges are attached to the framing, leaving its middle free to vibrate under the impulse received from the strings. It is supported by bars glued on to its back; but if these are made sufficiently strong to resist the tension of the strings, it is so stiffened as to prevent the requisite vibration; if otherwise, it is gradually forced out of shape so that its surface becomes curved, impairing the tone of the instrument. To remedy this, Mr. Dreaper of Liverpool applied hollow chambers to the back of the sounding board, adjusted to any desired pressure by screws.

M. Pape, for this purpose, placed the sounding-board at the lower side of a frame to the upper part of which the strings are attached, so that their effect should be to extend rather than compress the sound-board. This arrangement also admits of its being made of larger size, so as to increase the resonance.

The pitch of a note depends on the number of vibrations communicated to the air in a given time.

In the piano-forte the vibrations of the various strings, their intensity of sound, and their quality or timbre, are regulated in three different ways: by varying their length, their weight, or their tension. It is an established fact that of two strings of equal weight and tension, one which is half the length of the other produces a sound an octave higher, the intermediate notes between these being produced by strings varying in length according to a scale which has been ascertained by experiment.

The same result may be attained by varying the tension; in this case, the vibrations are in proportion to the square root of the force employed in stretching the strings. In strings of the same length and tension, but differing in weight, the vibrations are in direct inverse proportion to the respective weights of the strings. The relative pitch may be obtained by either of these modes, but in practice the piano-forte maker adopts them all, in order to produce the proper timbre and volume, as well as the required pitch.

In a grand piano-forte there are fourteen different thicknesses of steel wire, those for the bass being wrapped with thin copper wire, and each diminishing, but not uniformly, in length and tension, as well as in thickness, from the lower to the upper notes. Three strings were formerly employed for each note in the grand piano and two in the upright. Latterly, however, it is common to have but two strings for each middle and one for each lower note in the grand piano. Uprights have usually two strings for each note.

In 1827, Messrs. Collard patented a mode of applying the strings, differing from that previously in use; it consisted in employing but one hitch-pin of double the usual size, and passing the string from one tuning-pin to the other around this hitch-pin in one continuous piece of wire. By this the wires are prevented from twisting, and it obviates the danger of their snapping at the noose around the hitch-pin.

Another improvement consisted in giving the string an upward bearing at the striking end by employing perforated plates instead of the common form of bridges over which the string passed, the distance between them regulating the length of its vibrating part. The free end of the string was extended upwardly after passing through the perforated bridge, so that the upward blow of the hammer tended to force it against its seat in the bridge, instead of lifting it therefrom, as before.

Wornum, in 1819, reduced the strings to a uniform size and tension, wrapping those of the lower notes with wire to produce a lower tone.

This system, though possessing some advantages, never came into general use.

The mechanism by which the impulse is given to the key by the finger of the performer is termed the *action*. Those first employed were of the simple construction just described, known as *single action*. In this the hammer would not reach the string unless the key was struck with considerable force, so that it was impossible to play very *piano*, while, if it was attempted to remedy this defect by bringing the hammer nearer the string, there was danger of its not falling back, technically called *blocking*. This difficulty was obviated by the invention of the *hopper* (*b*, Fig. 3687). This is an upright jointed piece attached to the back end of the key, which, when the key is pressed down, engages in a notch on the under side of the hammer, lifting it so near that a very slight additional pressure causes it to strike; at this moment the upper joint of the hopper coming in contact with a fixed button, escapes or *hops* from the notch, allowing the hammer to fall away from the string. This is termed the *double action*, and still continues to be used in square and upright piano-fortes. In case the key was struck with too much force, however, the hammer was liable to rebound from the bed on to which it fell and strike the string a second time, impairing the tone of the note. To remedy this, a projection, the *check*, was fixed to the back end of the key, catching the edge of the hammer as it fell and preventing it from rising again. These actions, however, did not admit of the same note being struck twice in succession until the key had risen to its original position, so that the hopper could again engage in its notch. Various contrivances have been devised for enabling the quick repetition of the same note, all of which effect the object by holding the hammer up close to the string, while the key rises so that the hopper may sooner engage with it and repeat the note with less effort of the finger and greater rapidity.

Fig. 3687, *A* illustrates the square piano-forte action with the *Irish* damper, so called from its inventor Southwell, an Irishman; and *B*, the operation of the *check* and crank-damper. *a* is the key; *b*, the hopper; *c*, the string; *d*, Irish damper; *d'*, crank damper; *e*, under-hammer; *f*, hammer; and *g*, check.

The common *grand* action is shown at *C*. *D* represents Broadwood's grand action, and *E* the improvements thereto by Southwell. *a*, key; *b*, lever; *c*, button; *d*, check; *e*, damper; *f*, string; *g*, crank for damper; *h*, damper pedal-lifter; *i i i i*, rails and socket; *k*, spring; *l*, hammer; *m n*, block passed through the hammer-butt; *o*, a spring pressing against *n*, so that when the lever passes the notch in the foot of the hammer it is caught by *m*, retaining the hammer at the proper hight; *p*, a spring which determines the force with which the hammer shall strike.

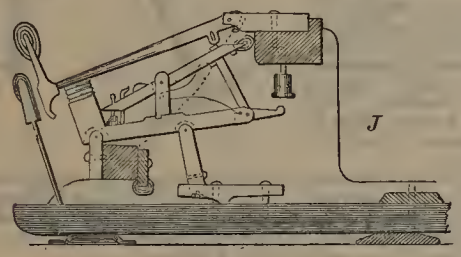
Collard's (properly, Stewart's) grand action is shown at *F*. *a*, key; *b*, hopper; *c*, button; *d*, hopper-spring; *e*, hammer; *f*, check; *g*, hammer-rail; *h*, damper; *i i*, rails; *k*, crank for damper; *l*, damper pedal-lifter.

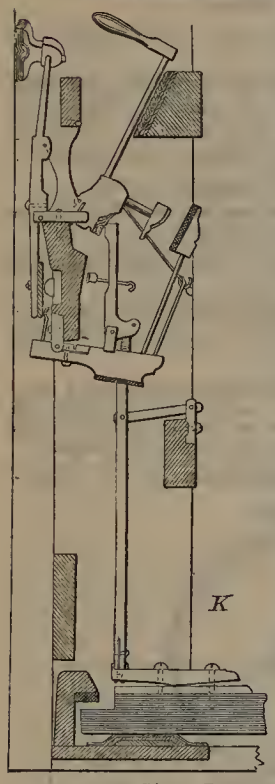
G is Erard's grand action. *a*, key; *b*, lifter; *c*, hopper-lever; *d*, hopper; *e*, hammer-sustaining lever; *f*, spring stop; *g*, hopper-button; *h*, butt against which the hopper strikes; *i*, two small wire stops which act against *e*; *k k*, springs acting upon hammer-lever and hopper-lever; *l*, check; *m m*, leaden balance-weights; *n*, damper; *o*, hammer; *p*, hopper-rail.

In addition to these may be cited two actions of Wornum's, designed for upright pianos; the first, *H*, known as the *unique*, and the second, *I*, as the *double* or *piccolo* action. In the first, *a* is the key; *b*, hopper; *c*, string; *d*, hammer-rail; *e*, hammer; *f*, damper and wire; *g*, damper-rail; *h*, ruler; *i i*, springs. In the latter, or double action, *a* is the key; *b*, hopper and springs; *c*, hammer; *d*, hammer-rail; *e*, tie and wire; *f*, check; *g g*, damper and wire; *h*, setting-off screw.

Many other forms, based on general principles similar to those illustrated, have been devised by inventors both in Europe and America. Prominent among these is the improvement of Pape, which consists in placing the action mechanism above, instead of below, the sounding-board, so that the blow of the hammer acts on the string from above, and no opening is required in the sound-board; by this arrangement a superior quality of tone is produced and the strength of the instrument increased.

Fig. 3688.





Steinway's Piano-Forte Actions.

In this the hammers are placed under the keys, and are worked from their front ends immediately below the part struck by the fingers, so that the thrust is transmitted directly downward in a nearly vertical direction. This arrangement also allows longer strings to be employed in proportion to the length of the case, or a shorter case with the same length of string, than in the usual piano-forte actions.

J K are, respectively, the horizontal and upright piano-forte actions of Steinway and Sons.

Others might be mentioned would space permit, embracing the peculiar constructions of instruments whose fame is wider than the continent, such as the Chickering, Knabe, Weber, Hallet and Davis, Schomacker, and others. On the stringing and construction of pianos, see "Lehrbuch des Pianofortebasses," Weimar, 1872.

In Pepys's diary, October, 1664, another form of stringed instrument played by keys is thus described: —

"To the musique meeting at the post-office, where I was once before. And thither anon come all the Gresham College, and a great deal of noble company; and the new instrument was brought called the Arched Viall, where, being tuned with lute-strings and played on with keys like an organ, a piece of parchment is always kept moving; and the strings, which, by the keys, are pressed down upon it, are grated in imitation of a bow by the parchment; and so it is intended to resemble several vialls played on with one bow, but so basely and harshly that it will never do."

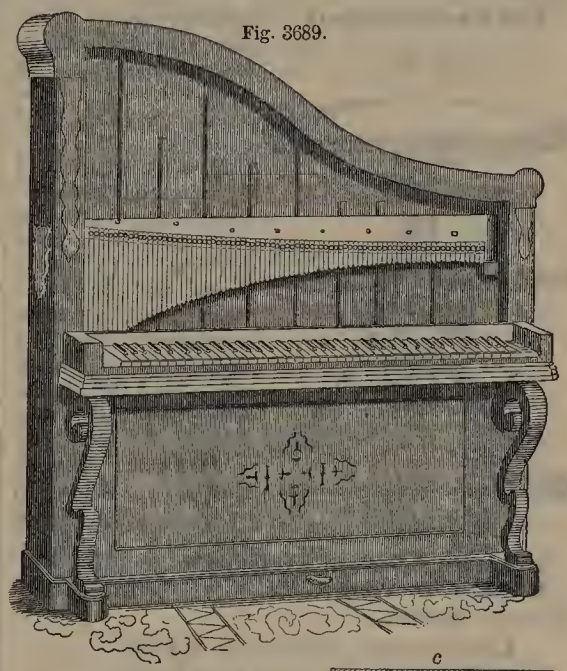
The self-acting piano has a pin cylinder turning horizontally on its axis, acted upon a coiled spring, and regulated by a fly-wheel. The pins have a determinate arrangement on the cylinder, like those of a barrel-organ or musical box, and act upon levers which actuate the hammers. Certain adjustments are made for piano and forte effects. Rolfe's English patent specifies a number of improvements.

The *violin attachment for piano-fortes* was patented in England about thirty years since by Todd. It is attached in addition to the usual hammer action, and is brought into use as required, being intended to confer upon the strings the violin tone, as a pleasing variation or accessory. This is effected by the pressure of the foot of the player upon a pedal, which puts in motion an endless band covered with resin, the band being made to rub against the particular wire appertaining to the key which is depressed by the finger of the player.

A writer has taken the trouble to give the actual material used in constructing a piano-forte: In an ordinary instrument there are fifteen kinds of wood, namely, pine, maple, spruce, cherry, walnut, whitewood, apple, basswood, birch, mahogany, ebony, holly, cedar, beech, and rosewood, from Honduras, Ceylon, England, South America, and Germany. In this combination, elasticity, strength, pliability, toughness, resonance, lightness, durability, and beauty are individual qualities, and the general result is *voice*. There are also used of the metals, iron, steel, brass, white-metal, gun-metal, and lead. There are in an instrument of seven and a half octaves 214 strings, making a total length of 787 feet of steel wire, and 500 feet of white (covering) wire. Such a piano will weigh from 900 to 1,000 pounds, and will last with constant use (not abuse) fifteen or twenty years. The total manufacture of pianos in New York alone averages 15,000 per annum. — *Exchange*.

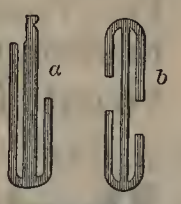
Fig 3689 illustrates an instrument patented July 11, 1871,

Fig. 3689.



Steel-Bar Piano.

by Messrs Atkins and Drewer, in which steel hooks *a b*, having one or more prongs, are employed in place of strings, the general arrangements of the key-board, action, and sounding-board resembling those of the upright piano. The hooks are attached to a metallic frame *c*, composed of two bars connected by pillars which alternate with the hook-supports, and cause the sound-board to vibrate by striking against it. When the hooks have more than one prong, each prong must be tuned to a different octave. A kind of *glockenspeil*.

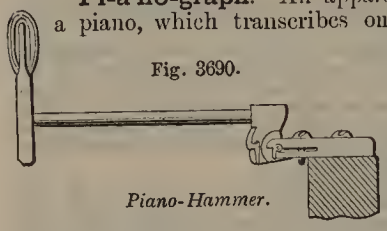


Pi-a'no-for'te Ac'tion. The motion-work of a piano-forte, including the key and hammer and the parts intervening. See Figs. 3687 and 3688.

Pi-a'no-for'te Ham'mer. The percussor in the piano movement which is impelled by the key and strikes the string.

Pi-a′no-graph. An apparatus attached to a piano, which transcribes on prepared paper the piece played on the piano.

Fig. 3690.

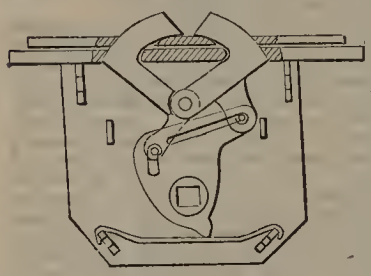


Piano-Hammer.

Pi-a′no-jack. (*Music.*) A feed-hand which drives the hammer in a piano. See Fig. 3687.

Pi-a′no-lock. One with curved or hooking bolts which clasp the keeper-plate of the piano-lid. In the illustration, the lock has two curved bolts, pivoted to a common center, and operated by the key through the medium of a tumbler-plate, which, describing the arc of a circle, passes through a plate screwed upon the lower surface of the lids of the piano.

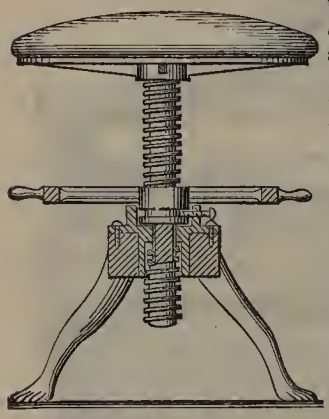
Fig. 3691.



Piano-Lock.

Pi-a′no-move′ment. The mechanism by which the vibration of the key is made to act upon the string. The *action*. See Figs. 3687 and 3688.

Fig. 3692.



Piano-Stool.

Pi-a′no-stool. A round-seated stool, capable of elevation or depression to suit the performer. In the example, the seat is vertically adjusted, without being rotated, by means of the hand-wheel and the sleeve-nut upon the screw-stem of the seat.

Pi-az′za. (*Architecture.*) *a.* A covered walk; a colonnade or arcade.

b. A central court in a building.

Pi′ca. (*Printing.*) A size of type between *Small Pica* and *English*.

Long Primer, 89 ems to a foot.

Small Pica, 83 ems to a foot.

Pica, 71 ems to a foot.

English, 64 ems to a foot.

Great Primer, 51 ems to a foot.

Double Pica, 35 ems to a foot.

The name is derived from the *Pie*, or table used before the Reformation for finding out the service for the day. *Pica* is the standard of measurement in casting leads, cutting rule, and regulating the price of work. Pica is also the unit of sizes for type above *Great Primer;* as *Two-line Pica, Four-line Pica,* etc.

Pic′co-lo. 1. A small upright piano, about 3½ feet high. Used for certain brilliant effects.

2. A small flute having a pitch an octave higher than the ordinary flute. An *octave-flute.*

Pic′co-lo-flute. (*Music.*) A wind-instrument like a flute, but one octave higher, and having nearly the same compass. A *piccolo.*

Pick. 1. A tool with a bent iron head, which has a point at each end and an eye in the middle, through which the handle is inserted perpendicularly. It is the tool of the quarryman, road-maker, and cellar-digger. In the example, it is shown connected to the helve by an iron strap.

Fig. 3693.

Picks.

The pick *b* of the miner is a somewhat smaller and neater implement, adapted to work in circumscribed situations. It is made of cast-steel with polished points, light, medium, and heavy weights, from 3½ to 8 pounds. See MINERS' TOOLS.

The foot-pick is used in prying out stones, in setting hedges, gardening, or otherwise. It is 3¾ feet long, and the tread is adjustable, but is ordinarily about 16 inches from the point.

The push-pick acts by thrust and endwise blow.

The lower figure on the left is a pickaxe.

2. A tool for dressing millstones. See MILLSTONE-PICK.

3. (*Weaving.*) The mode of estimating the rate of a loom as so many *picks* per minute. The *pick* is the blow which drives the shuttle, and is delivered upon the armed end of the shuttle by the *picker-head* on the end of the oscillating *picker-staff.*

Looms of 1800 ran about 60 picks per minute. In 1860, the power-loom was run at 220 picks per minute.

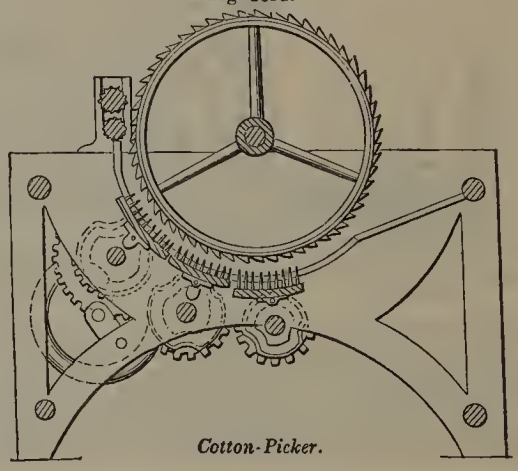
4. (*Printing.*) Foul matter and hardened ink collecting on type.

Pick′axe. An implement resembling a pick, except that one end of the head is broad and made sharp, so as to *cut.* See PICK.

The pickaxe of the United States artillery service is of iron, pointed at both ends with steel. Length of each blade, 6.5 inches; width of axe edge, 3 inches; handle (hickory), 1.5 inches by 1.25 inches; 30 inches long; weight, 6.5 pounds.

Pick′er. 1. (*Cotton-manufacture.*) A *cotton-*

Fig. 3694.



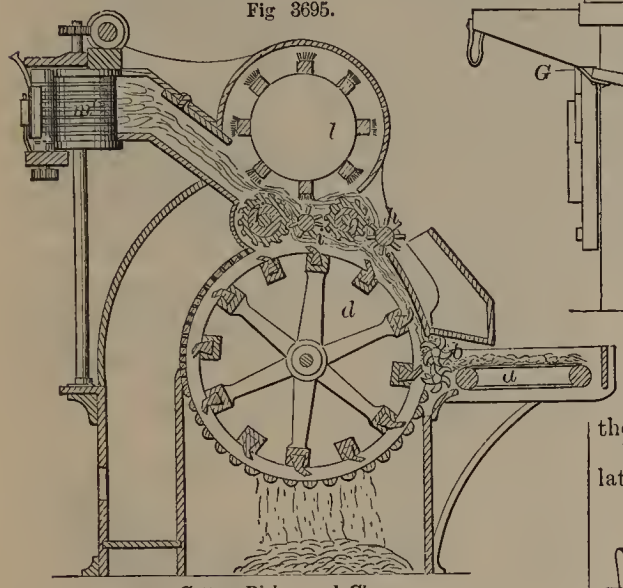
Cotton-Picker.

cleaner. A machine for opening the tussocks of bale-cotton, reducing it to a more fleecy condition, and separating from it dirt, burs, and other refuse.

In the machine, Fig. 3694, the cotton is fed in between rollers, caught by the teeth on the revolving drum, and drawn down against the teeth of the comb-plates, which act in succession upon the material, and each is cleaned by the withdrawal of its teeth through openings in a segmental apron partially surrounding the oblique-toothed picking-cylinder.

In Fig. 3695, the cotton or wool is fed into the machine by the endless apron *a* between rollers *b*, and is seized by the teeth of the picker *d*, which revolves in a slatted cylinder whose in-

Fig 3695.



Cotton Picker and Cleaner.

tervals allow dirt and dust to pass off, the operation being assisted by the centrifugal action of the air, resulting from the rapid rotation of the picker. The fiber is seized by other cylinders *f g*, and delivered from them by the pickers *h i*, which, in turn, are cleared by the brush-blower *l*, which drives the fiber up the spout to the condensing rolls *m'*, which deliver it in a lap.

In another form, the fleecy cotton from the willower is passed between fluted steel rollers, when a *beater* of two steel arms on a rapidly revolving shaft breaks it into fine fleecy masses. These fall on cylindrical sieves of wire, by the rotation of which they are carried in an even web to another series of rollers and beaters. When this process has been repeated several times, the *lap* or web of cotton passes between heavy iron rollers and is wound on a core of wood furnished with journals at the ends. See COTTON-CLEANER.

2. (*Cloth.*) A machine or an implement for *burling* cloth.

3. (*Husbandry.*) A machine for picking cotton from the boll in the field. See COTTON-PICKER.

4. (*Ordnance.*) A priming-wire for clearing the vent.

5. (*Menage.*) An instrument for dislodging a stone from the crease between the frog and the sole of a horse's foot, or between the heel of the shoe and the frog.

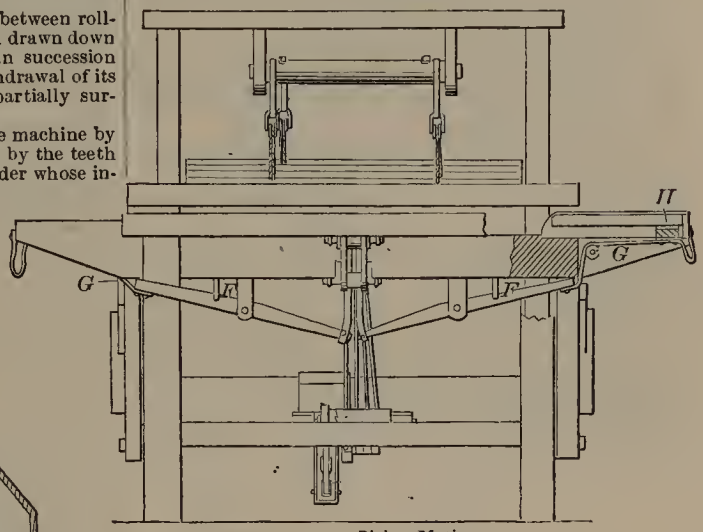
6. (*Founding.*) A light steel rod with a very sharp point, used for picking out small, light patterns from the sand.

7. (*Weaving.*) The upper or striking portion of a *picker-staff* which comes against the end of the *shuttle* and impels it through the *shed* of the *warp*. It requires a tough and somewhat resilient material; the former that it may last, the latter that it may not injure the shuttle. Raw-hide is frequently used.

The usual form is a staff sweeping in a vertical plane, and operated opportunely by means of the lay, or through gearing, according to the construction of the loom.

In Fig. 3696, the picker-blocks are operated from the lay by a system of rollers and straps. Pulling on the straps raises the ends of the levers *F F* in alternation, causing them to pull the straps *G G*, which actuate the picker-blocks *H*.

Fig. 3696.

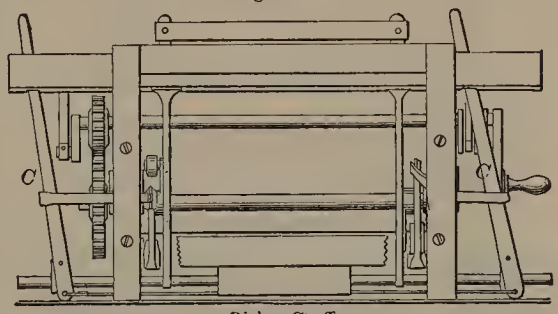


Picker-Motion.

Pick'er-mo'tion. (*Weaving.*) The system of parts involved in impelling the shuttle through the shed. See PICKER.

Pick'er-staff. (*Weaving.*) The bar which oscillates on an axis at its lower end, and by a sudden

Fig. 3697.

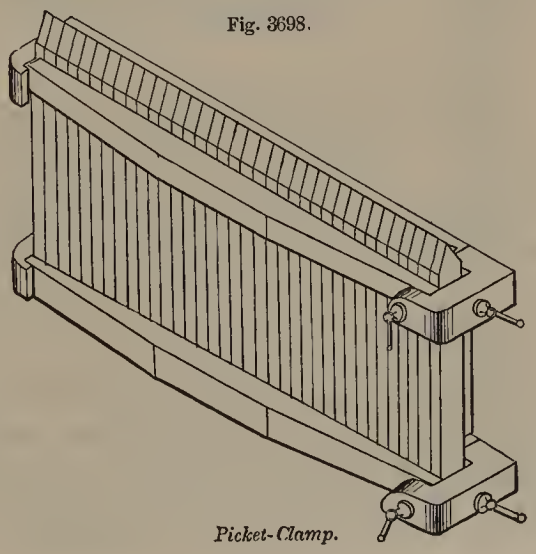


Picker-Staff.

jerk imparts motion to the shuttle. The staffs in the example are shown at *C*, and are moved automatically by the motion of the lay.

Pick'et. 1. (*Fortification.*) *a.* A stake with a

Fig. 3698.



Picket-Clamp.

sharpened end, used in laying off ground for fortifications.

b. A stake sharpened at both ends; one driven into the ground and the other acting as an obstacle to the advance of an enemy.

2. (*Husbandry.*) A pale of a fence.

3. (*Surveying.*) *a.* A staff used with a surveying chain by the leader and follower, being passed through the end rings.

b. A marking stake to indicate positions or stations.

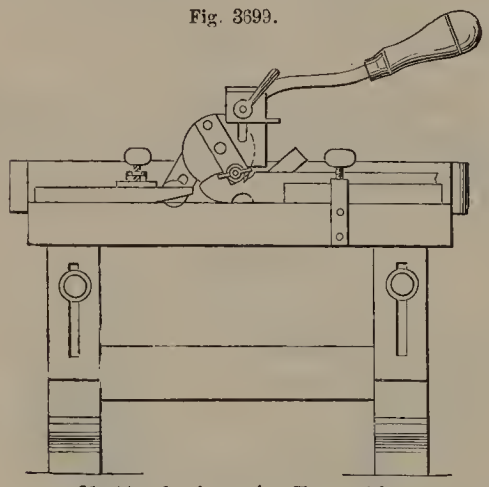
4. (*Menage.*) A stake to which a horse is tethered.

Pick'et-clamp. A device to hold pales while being dressed to shape.

Pick'et-pin. (*Menage.*) An iron pin about 14 inches long, having a rounded head and a ring near the head, to which the lariat rope is fastened. It is driven into the earth, the rope permitting the horse to graze for a limited distance around it.

Pick'et-point'er. A machine for dressing the heads of fence pickets or pales. In the example, an

Fig. 3699.



Machine for sharpening Fence-Pickets.

oscillating plate, carried on the frame on which the pickets are placed, has a cutter attached to either the upper or under part of its face, according as a convex or concave cut is to be made.

Pick-ham'mer. A hammer with a pointed *peen*, used in *cobbing*; that is, spalling off the inferior portions from blocks of ore. A *pick*.

Pick'ing. 1. (*Fiber.*) *a.* A process in which deviled wool is examined for foreign matters and impurities. *Burring* is a substitute operation.

b. See PICKER.

2. (*Metallurgy.*) Rough sorting of ore.

Pick'ing Cloth. One of the finishing processes of cloth. It is subjected to a strong light, and all blemishes removed from its surface by tweezers. Spots which have escaped the action of the dye are touched with dye by a camel's-hair brush. *Burling.*

Pick'ing-peg. (*Weaving.*) The piece which strikes the shuttle and drives it through the shed. In one form of hand-loom, the picking-peg is drawn by a cord. In the power-loom the driver is on a vibrating staff.

The *picker* is the invention of John Kay, about 1750, and the shuttle thus operated was called a *fly-shuttle*, from the rapidity of its movement as compared with the hand-shuttle.

Pick'ing-stick. (*Weaving.*) The picker-staff for driving the shuttle of a power-loom.

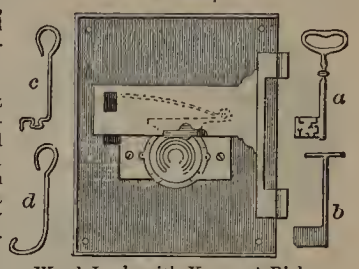
Pick'le. 1. (*Founding.*) A bath of dilute sulphuric acid to remove the sand and impurities from the surface; and at the present day this treatment is by no means confined to small castings. It saves much labor and improves the appearance of the work. Dilute nitric acid is sometimes used for brass.

2. The pickle for brass castings previous to lacquering is dilute nitric acid.

Pick'lock. A flexible or a bent wire or small rod, which avoids the wards of a lock and serves to open it.

The illustration shows an expensive form of ward-lock used some years since on the strong-room of a bank. The wards are shown, surrounding the central key-pin, and from the appearance of the key, shown at *a*, it is evident that these wards must have been rather complex. A burglar employed an instrument shaped like that at *b*, having on one of its faces or sides a layer of wax and yellow soap; this instrument being introduced through the keyhole and turned a little way round, brought the soft composition in contact with the ends of the wards, and these ends thus left their impress on the composition. A false key was then made, as at *c*, which has a vacuity where there is a cavity in the true key; and by this instrument the lock was opened. The flexible instrument *d*, by passing round the wards, might open such a lock.

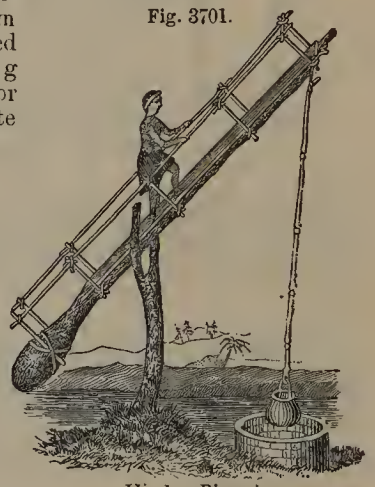
Fig. 3700.



Ward-Lock with Key and Picks.

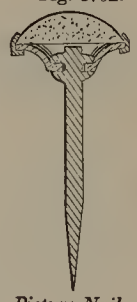
Pi-co'tah. A kind of *sweep* used in India to raise water for irrigation, the beam having a stepped foot-way, along which the operator walks to oscillate the beam.

Fig. 3701.



Hindoo Picotah.

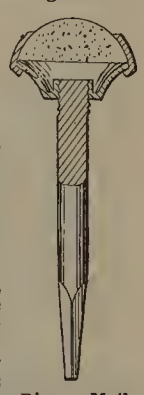
Fig. 3702.



Picture-Nail.

Pic'ture-nail. An article of household hardware. It has a shank capable of being driven into a wall while the head is yet detached. Afterward, the porcelain, glass, or gilt head is screwed to the shank.

Fig. 3703.



Picture-Nail.

Pi. (*Printing.*) Type mixed indiscriminately.

Pie. A fruit or meat pasty. Our interest in it concerns the machinery involved.

In the works of the New York Pie-Baking Company, the ground-floor is used as a retail department. In the rear are the bakery, store-rooms, ice-house, wagon-sheds, etc. In the basement are the ovens, ten in number, measuring ten by twelve feet, also a rotary oven, which will bake nine hundred pies per hour. The first floor above contains the engine, boiler, and delivery rooms. The second floor is the pastry department, where the mixing of the dough is done, and the third floor is devoted to the preparation of fruit, etc. On this floor is a huge range, capable of cooking ten barrels of fruit at once, also two copper steam-kettles with a capacity of two barrels each. An elevator hoists and lowers the pies and material of which they are composed.

The weekly consumption of materials is 140 barrels of flour, 12,000 pounds of sugar, 5,000 pounds of lard, 500 barrels apples, 30,000 pounds pumpkins and squashes, 60,000 eggs, 500 bushels berries in their season, 800 pounds beef for mince, 1,500 pounds cocoanut, 100 boxes lemons, and spices accordingly. They also have in constant use about 150,000 pie-plates, and give employment to 100 workmen, running 35 wagons.

Pie-board. A board on which dough is rolled thin for making pastry.

Piece. (*Bookbinding.*) A tablet of leather occupying a panel on the back.

Piece-dyed. Cloth dyed after weaving.

Pie-droit'. (*Architecture.*) A pier attached to a wall. It has neither cap nor base, and therein differs from a pilaster.

Piel. An iron wedge for boring stones.

Pier. (*Architecture.*) 1. *a.* A detached pillar or wall supporting the ends of adjoining trusses or spans; or the springers of adjacent arches. See CAISSON, for mode of sinking piers.

The term *standing* pier is sometimes applied to the isolated structure; *abutment* pier to a wall from which springs the landward arch of a bridge.

The piers of the bridge of Semiramis across the Euphrates at Babylon were made of hewed stones secured by iron cramps and melted lead. — DIODORUS SICULUS.

Fig. 3704 is a sectional view of a pier made in sections.

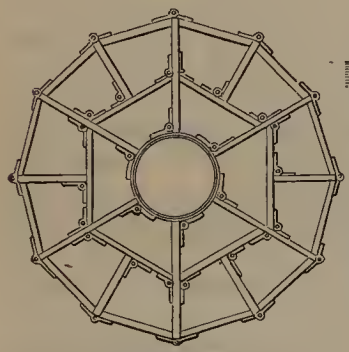
b. The portion of a wall between the windows or doors.

c. An upright projecting portion of wall, similar to a pilaster, throwing the intervening sunken portions into panel. See RUBBLE-MASONRY.

d. A buttress.

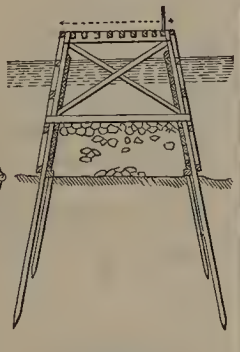
2. A mole or jetty extending out from the land into the water, adapted to form a landing-place for

Fig. 3704.



Sectional Pier.

Fig. 3705



Hull-Pier.

passengers or merchandise from ships which float in the deep water alongside the pier or wharf.

They are variously constructed. Some are founded on piles, with cross-timbers, braces, and sheathing; floor-timbers afford a road for the traffic. The wooden structure is sometimes filled up with stone, like a dike; at other times it is of the nature of trestle-work.

Many elegant adaptations of iron to this work are found in Europe.

Piers of regular masonry are also common. They are founded on piles and built after the manner of bridge piers, with coffer-dams and the usual accessories.

Pier-arch. (*Architecture.*) An arch supported on a pier.

Pier'cel. A gimlet for opening vent-holes in casks of liquor.

Pierc'er. 1. A bow-drill.

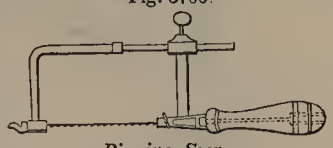
2. (*Founding.*) A vent-wire.

3. The sailmaker's awl.

Pierc'ing-file. A sharp and narrow file to enlarge a narrow drilled hole.

Pierc'ing-saw. A thin blade fastened by screw-clamps in a light frame, and used for piercing gold and silver smiths' works. Holes are drilled in the plate and the saw introduced; being then secured in the frame, the blade is reciprocated and caused to follow the lines of the templet or those which are inscribed thereon. A *buhl-saw.*

Fig. 3706.



Piercing-Saw.

Pier-elle'. A mass of stones filling a ditch and covered with clay.

Pier-glass. A large looking-glass between windows, frequently standing on a *pier-table.*

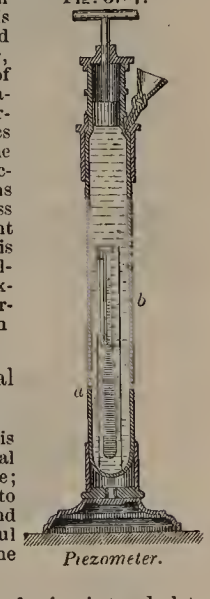
Pierre Per-due'. A foundation formed of masses of stone thrown in at random, as in the construction of the Plymouth Breakwater, the Rip Raps, the foundation of Fort Sumter, and many other public works in various countries.

Pi-e'tra Du'ra. A species of inlaid work composed of hard stones, such as agate, jasper, chalcedony, carnelian, and lapis-lazuli, set in a slab of marble, generally black. The marble is worked to a thickness not much exceeding the eighth of an inch; the design is drawn upon it and cut out with the saw and file. The hard stones, formed to the desired shapes by the usual processes of gem-cutting, are accurately fitted into the spaces thus cut out, and the whole is attached as a veneer to a thicker slab.

Pi'e-zom'e-ter. An instrument invented by Oersted for measuring the compressibility of liquids.

It consists of an elongated bulb *a* having a graduated stem of small bore. The instrument is filled with any liquid up to a certain mark on the stem, and a globule of mercury is placed above the liquid. It is then placed in a cylindrical vessel *b* filled with water, to which pressure is applied by means of a screw piston. The number of graduations through which the globule of mercury is thus caused to descend indicates the apparent diminution in bulk of the liquid; that is, the excess of its contraction over that of the bulb which contains it. This depends on the quality of the glass of which the bulb is composed; its amount is ascertained and the proper correction is applied by deducting the increase in volume due to the difference of the two expansions, from the indication of the mercurial index; this gives the absolute contraction of the liquid.

Fig. 3707.



Piezometer.

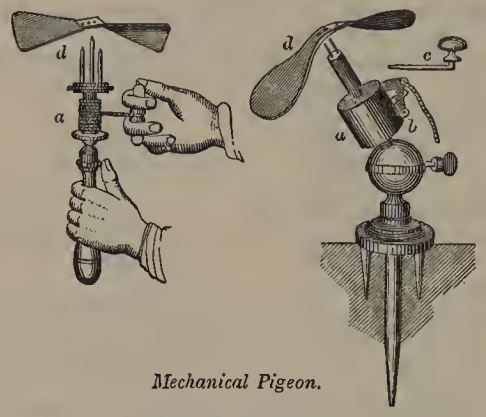
Pig. An oblong mass of metal as run from the smelting-furnace.

A main channel, called the *sow*, is scraped in the floor, into which the metal flows from the *tapping-hole* of the furnace; on each side of this are shallow ditches to receive the metal from the main stem, and the laterals are called *pigs* from a fanciful resemblance to the sow and pigs of the main trunk and the laterals.

Pig'eon, Me-chan'i-cal. A device intended to practice sportsmen in the art of shooting birds on the wing.

It consists of a thin strip of sheet-iron *d*, six or more inches long, having wings bent after the manner of screw-propeller blades; when rapid rotation is imparted to the device, it rises in the air, its appearance when in motion resembling that of a flying bird. The rotary motion may be given either by rapidly pulling a string wound around a spool *a* or by means of a spring contained within a cylinder *a* and compressed by turning a pin or key *c* inserted in a hole in the pronged axis on which the

Fig. 3708.

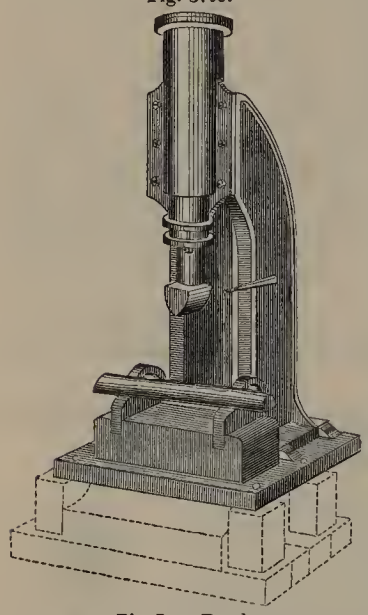


Mechanical Pigeon.

"pigeon" is placed; the spring is released by pulling the trigger *b*, to which a string of any desired length may be attached.

Pig-i'ron Break'er. A form of power hammer for breaking pigs of iron into pieces fit for charging into a furnace. It is otherwise done by sledges.

Fig. 3709.



Pig-Iron Breaker.

Pig'ment. A coloring material. A *paint*, *dye*, or *stain*.

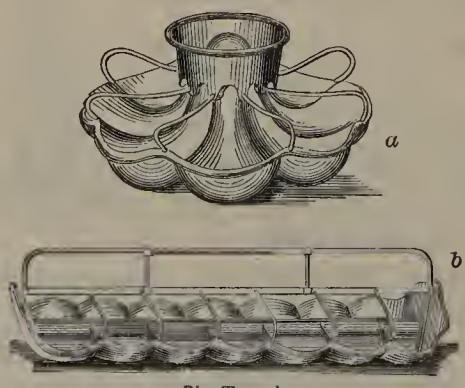
Pig'ment-print'ing. A style of calico-printing in which ordinary pigments are mechanically attached to the cloth by albuminous cement.

Pig-nose Vise. A hand-vise with narrow, pointed jaws.

Pig'tail. (*Nautical.*) A form of knot worked on the end of a cable or rope. See KNOT.

Pig-trough. In Fig. 3710, *a b* are two varieties of cast-iron troughs, designed to prevent pigs from wasting the food or interfering with one another while

Fig. 3710.



Pig-Troughs.

eating. This is effected by curved bars at a proper hight between each division of the trough.

Pike. A shaft of wood armed at the end with a sharp metallic head. A spear. A weapon used in repelling boarders. A *boarding-pike*.

In all times down to the invention of the bayonet it has formed a weapon for infantry in line or in mass. After the invention of the bayonet it was, for a time, mingled with the bayonets. It is not now to be found in the armies of Europe in the hands of infantry.

Pi-las'ter. (*Architecture.*) A square pier, like a flat column, built against a wall, and having cap and base.

Flank pilasters are known as *antæ*.

A *piedroit* is a pier against a wall, and having neither base nor cap.

Pile. 1. (*Hydraulic Engineering.*) A beam or timber driven into treacherous ground to form a foundation for a structure, or to form part of a wall, as of a coffer-dam or quay.

Piles are known by their structure.

Hollow pile.	Screw-pile.
Pneumatic pile.	

Or, —

Close pile.	Gage-pile.
False pile.	Guide-pile.
Filling-pile.	Sheathing-pile.
Foundation-pile.	Sheet-pile.

A *pneumatic* pile is one driven by the atmospheric pressure when the air is exhausted from within it.

A *hollow* pile is a cylinder which is sunk by excavation proceeding inside.

A *screw* pile has an auger at the lower end, and is sunk by rotation aided by pressure beyond its own weight, if necessary.

A *close* pile is one of whole timber, set closely to the others on each side.

A *false* pile is an additional length given to a pile after driving.

A *filling* pile is to fill the space between gage-piles.

A *foundation* pile is one for supporting a structure.

A *gage* pile is a preliminary pile to mark the desired course.

A *guide* pile limits the field of operations.

A *sheet* pile is of half-timbers in contact, filling the gaps between gage-piles.

A *sett* is a temporary prolongation at the upper end when a pile has passed beyond the stroke of the hammer.

A *wale* is a horizontal string-piece to bind the piles.

The *refusal* of a pile intended to support a weight of 13½ tons can be safely taken at ten blows of a ram of 1,350 pounds falling 12 feet, and depressing the pile .8 of an inch at each stroke.

Pile-cap; a beam connecting the heads of piles.

Pile-hoop; a band around the head to prevent splitting.

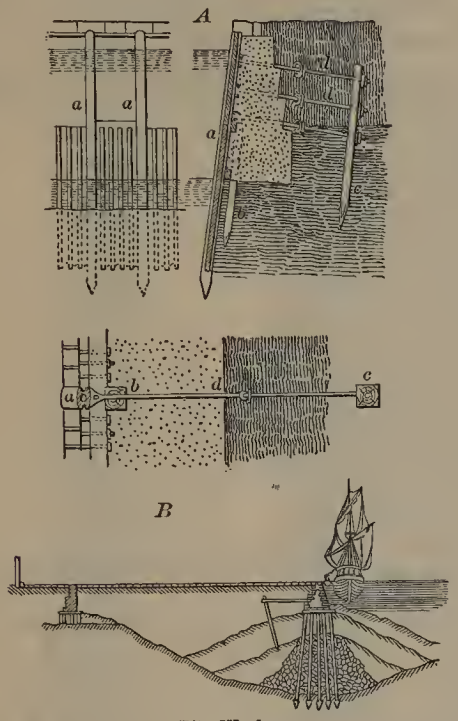
Pile-shoe; the metallic point.

The quay at Lorient is erected upon a bed of mud of unfathomable depth, and in this case both the wall and the platform behind it are carried upon piles driven with the broad end downward.

In Fig. 3711, *A* is an elevation, plan, and section of the system of cast-iron piling employed in the construction of wharves at Deptford and Blackwall, England. The main piles *a a* have rabbets on each side, into which the sheeting is driven, and are secured at the back by stays and a thick bed of concrete; *b* is a guide-pile; *c*, a stay-pile; and *d*, land-ties. In driving, a piece of timber two inches thick was placed on each pile to relieve the jar of the ram, which weighed 15 cwt., and was allowed to drop but four feet.

The piles used in extending the quay of Rouen (*B*) were from 12 to 15 inches thick, and were driven with a monkey of 1,200 pounds falling 20 feet, delivering a blow equal to a pressure of 300,000 pounds. The heads of the piles were cut off 6 feet below low water, and stones were piled in. Caissons were sunk on to the piles, and in them the masonry was constructed. Each pile was calculated to support 18,633 pounds of masonry, and an

Fig. 3711.



Pile-Work.

estimated addition of one half for merchandise gave each pile a load of 27,000 pounds.

The quay was advanced 120 feet from the original wall. Sand and gravel were filled in behind the new wall, and the area was paved.

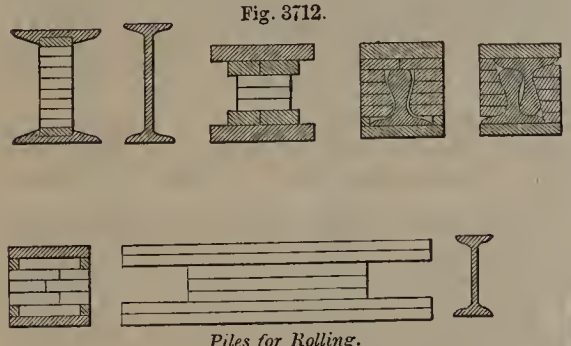
Hollow Pile. In situations where piling cannot be used to advantage, wrought or cast iron cylinders have been sunk vertically by digging away the soil from below them, the workmen operating inside and sending the earth up the iron shaft, which is like a well-curb. The water is pumped out as the work proceeds, and the sections of pipe are added from time to time, being fastened together by flanges and bolts. This plan has been frequently adopted in well-digging.

In the construction of the Terrace Pier, Gravesend, England, Redman constructed his foundations by sinking cast-iron cylinders in the manner stated, and filling them with a concrete of sand and pozzuolana, which made solid stone columns.

In the foundations of the Town Pier, Gravesend, England, erected 1834, Mr. Clark used a system of cast-iron piles. Under the site of each column were driven three cast-iron piles, on which an adjusting plate was firmly keyed, forming a broad base for the support of the column, which was adjusted to its correct position, and bolted down to the adjusting plate.

2. (*Iron-working.*) A pile of iron bars for reheating or balling consists of a number of pieces cut by

Fig. 3712.



Piles for Rolling.

shears to the size best adapted for the finished bar required, and then built up one over the other, according to the bulk required. The *pile* or *fagot* is then charged into the balling-furnace.

Piles are sometimes made up approximating a peculiar form required, as in some of the examples, and the various qualities of iron are so disposed in the different parts of the pile as to

Fig. 3713.

Piles for Rolling into Beams.

bring them where a special quality is desirable. See also FAGOT; BEAM; IRON, ANGLE, pp. 1198, 1199.

3. A series of plates, as of zinc and copper alternately, in an exciting solution. A *voltaic pile.*

4. A stack of arms. See STACK.

5. A regular heap of shot or shells.

6. The *reverse* of a coin. The side occupied by the *arms.*

Formerly, the planchet was placed on a stake on which was a *cross*, and the *pile* or punch with the *arms* was driven by a hammer. The *cross* is now superseded by the *head*, which occupies the *obverse.*

7. (*Fabric.*) A fabric in which the warp is formed into loops which project from the face of the goods. When left in this condition, the goods, according to material and quality, may be, —

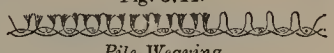
Uncut velvet.
Beavertcen.
Brussels carpet.

When cut, it may be, —

Turkey, Persian, or Wilton carpet.
Cut velvet.
Velvetcen.
Plusb.

In *pile-weaving*, in addition to the usual warp and weft threads, a third thread is introduced in the course of the weaving, and is thrown into loops by being woven over wires of the breadth of the cloth.

Fig. 3714.



Pile-Weaving.

In *Brussels* carpet and *uncut velvet* the wires are simply withdrawn and the loops left standing. In *Wilton* carpet and *velvet* the threads are cut by passing a sharp knife along a director groove on the upper surface of the wire. This forms a nap, and is found in certain carpets, velvet, velveteen, fustian, etc.

In the *Imperial Brussels* the figure is raised above the ground and its *pile* is cut, but the ground is uncut. In the *Royal Wilton* the pile is raised higher than in the common Wilton, and is also cut.

See under the following heads: —

Bearing-pile.
Beetle-head.
Bridge-pile.
Close pile.
Dolly.
False pile.
Fender-pile.
Fistuca
Gage-pile.
Galvanic pile.
Guard-pile.
Guide-pile.
Monkey.
Monkey-engine.
Pile-carpet.
Pile-drawer.
Pile-driver.
Pile-fabric.
Pile of iron bars for reheating.
Pile-saw.
Pneumatic pile.
Punch.
Ram.
Ringing-engine.
Screw-pile.
Sett.
Sheathing-pile.
Sheet-pile.
Short pile.
Stay-pile.
Stilts.
Tongs.
Voltaic pile.
Wall.

Pile-bridge. A bridge whose roadway is constructed on piles. An excellent plan over extensive shallow waters but little obstructed by ice, as that of the Wilmington and Baltimore Railroad over Gunpowder River, and many other places.

Cæsar's bridge (page 379) was also a pile-bridge with trestle superstructure.

Pile-cap. (*Hydraulic Engineering.*) A beam connecting the heads of piles.

Pile-car'pet. A carpet made like BRUSSELS CARPET (which see), exeepting that the loops are eut, forming a *pile* or downy surfaee. For *pile* or *Wilton carpet* the wires are flattened, and have a groove along the upper surface, which forms a direetor for the knife, which euts all the loops and liberates the wire.

Pile-clamp. (*Surgical.*) An instrument for removing hemorrhoids.

In the example, the two blades are made to close perfectly parallel by means of a screw, so as to equally compress the mass to be separated. This is afterward removed by the knife or by

Fig. 3715.

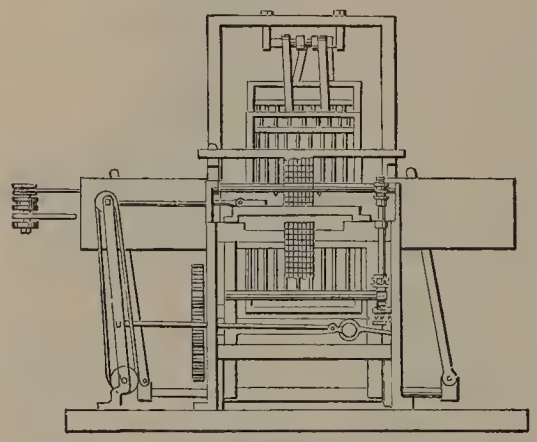
Pile-Clamp.

strangulation. The surfaces of the blades, which are applied to the integuments of the patient, are faced with ivory to prevent heat heing communicated to the sensitive parts during the process of cauterization

Piled-fab'ric Loom. One for weaving velvet, Brussels carpet, or plush.

In some cases, as in the example, two united piled fabrics are woven simultaneously and cut apart by a revolving kuife oper-

Fig. 3716.



Piled-Fabric Loom.

ating in connection with a guard-finger in the loom to form velvet and similar goods. To vary the length of the pile, the guide-bars are set nearer or farther apart.

Pile-draw'er. (*Hydraulic Engineering.*) When not too firmly imbedded, piles may be drawn by means of a simple lever. A serew set in a strong framing and turned by a windlass or crab may also be employed. Still greater power may be attained by the employment of the hydrostatic press. In tide-waters, a barge or scow can be made fast to the head of the pile at low water ; this is a very effectual mode if the boat have sufficient elevating eapacity. In either case, the attaehment must be very secure. This is sometimes effected by boring a hole through the head of the pile and inserting an iron pin, projecting on either side ; over the ends of this are passed iron rings or loops made fast to the lifting rope or chain. When the whole of the pile is below water, so that it is not accessible for this purpose, an elliptical iron eollar is slipped over the head of the pile, and is caused to bind by hauling on the rope, the angles of its upper and lower edges bearing against the wood.

Pile-driv'er. (*Hydraulic Engineering.*) A maehine having a rising and falling weight to drive a pile into its bed.

It is suggested that the *fistuca* whereby Cæsar drove the piles of his bridge over the Rhine must have been something similar to our machine, in which a weight is alternately lift-ed aud dropped on the head of the pile.

Fig. 3717.

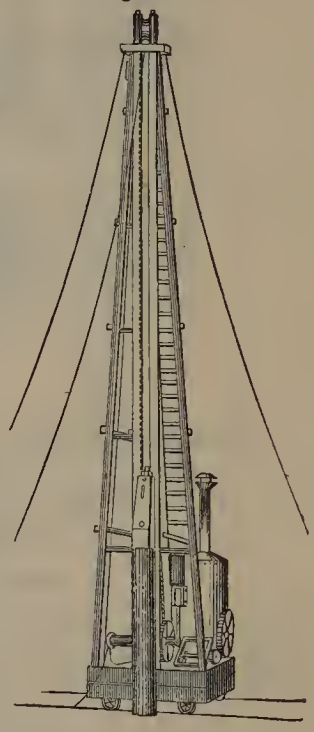
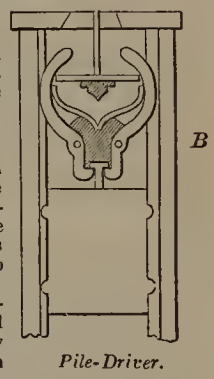


Fig 3717 is a view of a steam pile-driver, in which the *monkey* is raised by a steam-hoist and automatically detached on reaching its hight. A pair of nippers, as seen at *B*, engages the hook on the top of the weight, and is kept in a closed position by springs. As the handles of the nippers reach the slot in the bar above, they are pressed together, releasing the jaws from the hook of the weight and allowing it to drop on the head of the pile.

Some conception of the rapidity with which piles are driven by this machine may be formed, when it is stated that a pile measuring 60 feet in length and 14 inches square can be driven 45 feet into stiff soil, down to the rock below, in four minutes; and such is the good effect resulting from the blows being given by a great mass of 30 cwt. striking quickly but with small velocity of actual impact, that the head of the pile requires no hoop, and presents, after being driven, a neater appearance than it had when it was first placed under the hammer.

Fig. 3718 is another kind of apparatus. *A* is an end; *B*, a side elevation; *C*, a plan of Nasmyth's steam pile-driver. The driving-apparatus *a b c* and pile are raised by a windlass operated by a small detached steam-engine, the former resting on the shoulders of the pile; the lifting-chain is then detached and steam from the boiler is admitted through the jointed pipe *d* into the cylinder *b*, alternately above and below the piston, the ram *c* giving a rapid succession of blows to the head of the pile until driven to the required depth, the jointed pipe *d* gradually following its downward movement. The pile and driver are guided in their descent by clamps, which loosely grasp a guide-rail at the side of the main upright.



Pile-Driver.

In Shaw's pile-driver, the monkey is sustained at its highest elevation by means of a ratchet and pawl, while a cartridge and cap are placed in a recess in the head of the pile. The pawl being withdrawn, the monkey falls upon and explodes the cartridge. The force of the explosion raises the monkey to the hight from which it fell, where it is automatically arrested by the detent arrangement

The effective force of the fall is said to be much increased by the action of the powder. One man places the cartridge in position and releases the monkey, or, as it is sometimes called, the *ram*. See GUNPOWDER-HAMMER.

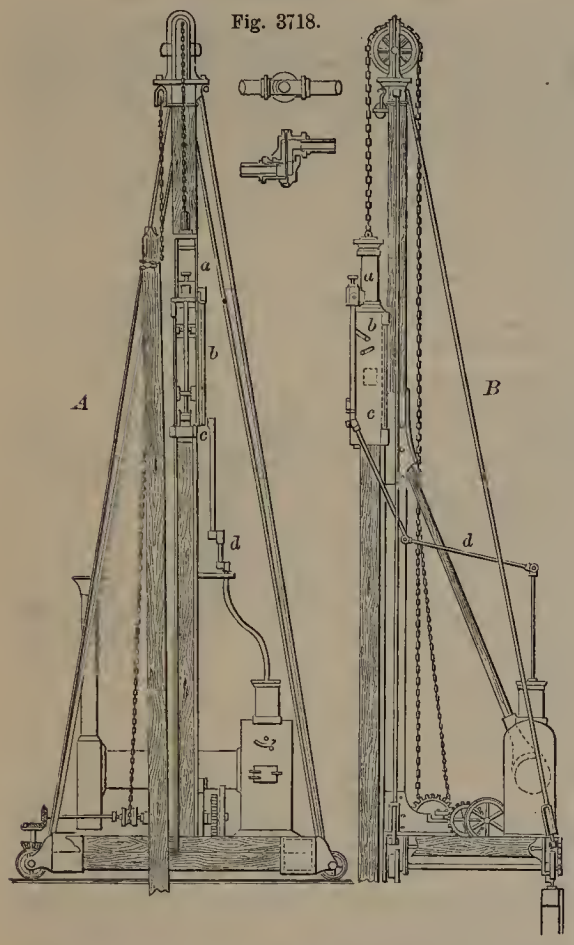
Pile-fab'ric. One in which a looped weft is formed by wires, to be afterward cut, as in velvet and in Wilton carpet, or left in loops, as in Brussels carpet.

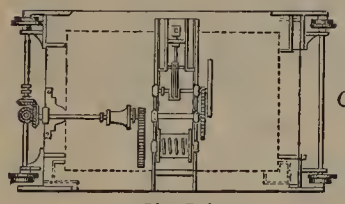
Pi-len'tum. A light vehicle, something between a cab and a carriage.

Pile-pier. (*Hydraulic Engineering.*) One supported on piles.

Pile-saw. The saw for cutting off piles below the surface of the water was invented by Labelye in planning the operation for establishing foundations for the piers of the Westminster Bridge, 1738, and improved by De Cessart, when building the bridge

Fig. 3718.



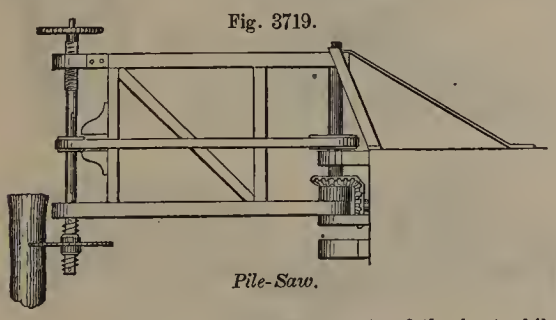


Pile-Driver.

of Saumur, 1756–64. In a simple form the machine consists of a frame composed of two longitudinal and three transverse timbers; to the central transverse piece are attached two uprights projecting above and below the frame, the saw being inserted between their lower ends, and their upper ends connected by a tension-rod for stretching the saw; handles are attached to the longitudinal piece of the frame, through which a reciprocating motion is given to the apparatus by the workmen, who stand on a platform.

Fig. 3719 is Vogler's pile-sawing attachment for boats. The circular saw is keyed on an upright shaft in a frame rigged outboard from the boat; it is secured between spiral springs above

Fig. 3719.



Pile-Saw.

and below, which yield to the movements of the boat while cutting is going on, and is driven by belting from a shaft at that side of the frame nearest the boat, and rotated by bevel-gears operated by machinery on board.

Pile-shoe. (*Hydraulic Engineering.*) An iron joint at the foot of a pile, to enable it to penetrate hard ground. It may be a hollow pyramid of cast-iron; or two wrought-iron straps crossing at right angles may be secured to the foot of the pile.

Pile-sup-port'er. A *suppository* for preventing protrusion of the rectum.

Rabbi Moussa Ben Maimon wrote on hemorrhoids. He was known over Europe as the "Great Sage" Maimonides, and often designated by his initials R. M B. M., or, briefly, Rambam. He was born at Cordova, A. D. 1135, but emigrated to Egypt, and became physician to Sultan Saladin. See SUPPOSITORY.

Pile-warp. A warp which is woven in loops on the face to form a nap.

Pile-wire. (*Weaving.*) The wire around which the warp-threads are looped to make a pile-fabric. When the pile is to be cut, like velvet or plush, a groove on the top of the wire acts as a director for the knife.

Pile-with-draw'ing Ma-chine'. (*Hydraulic Engineering.*) A machine, usually a screw, worked by levers in the manner of a capstan, and connected by chain to the pile. See PILE-DRAWER.

Pil'ing. 1. (*Metallurgy.*) Building up pieces of sheared or scrap iron into a pack suitable for heating in a balling or reheating furnace, which forms the pile into a *loop* suitable for rolling. See PILE; FAGOT.

2. (*Leather.*) Unhairing hides by piling or hanging up in a *stove*, so called.

Pill. Medicine in the form of a small ball, larger than a pellet.

Large pills of metallic antimony constituted a favorite ancient remedy, which were administered and passed through the system with no more effect than so many little pebbles. Indeed, the same pills were used over again, and half a dozen such globules lasted for an unlimited time, being inherited in the family and performing innumerable supposed cures upon successive generations. This was not so very long ago.

Pills in a box and rolls of material for making them were found in an apothecary's house in the disentombed Herculaneum.

Pil'lar. 1. (*Architecture.*) A column or pier forming an upright insulated support for a superstructure. The word is rather applicable to those of the Gothic and other irregular styles of architecture than to the Grecian and Roman orders, which are somewhat determinately proportioned and known specifically as columns.

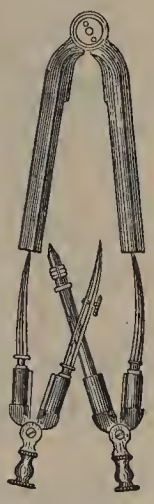
A round pillar is a *column*.

A square pillar is a *pier*.

A flat pillar with a narrow return and apparently built into a wall is a *pilaster*.

A pier, similarly placed but without cap or base, is a *piedroit*.

Fig. 3720.



Pillar-Compass.

2. (*Mining.*) The post or mass of coal or ore left for the support of the ceiling of a mine. The worked space is called *room*. Thus, *pillar and room* is equivalent to the usual technical phrase, *post and stall*.

3. (*Shipbuilding.*) A vertical post beneath a deck-beam.

4. The nipple of a fire-arm.

5. A frame on which the tobacco-pipes rest in a kiln.

6. (*Horology.*) One of the posts in a watch or clock which separate and yet bind together the *plates*.

Pil'lar-block. A corruption from PILLOW-BLOCK (which see). See also PLUMBER-BLOCK.

Pil'lar-com'pass. A pair of dividers, the legs of which are so arranged that the lower part may be taken out, forming, respectively, a bow-pen and bow-pencil, or, by in-

verting them in their sheaths in the upper part of the leg, a compass with a pen or pencil point is formed.

Pil'lar-file. A narrow, thin, flat hand-file with one *safe* edge.

Pill-box. One for containing little balls of medicine.

Some pill-boxes are made from *scaleboard* covered with paper. Plank have been cut into scales 120 to the inch, but $\frac{1}{30}$ of an inch is a more usual thickness. The scale is cut into pieces the size of a box, grooved half-way through where the sides and ends turn up, formed, the corners glued, and covered with thin paper. The after addition of bright-colored paper gives the box an ornamental appearance.

Pasteboard is used in the same way as scaleboard as a foundation for pill-boxes.

A veneer somewhat thicker than scale is cut into pieces for boxes, one die cutting the top, another the bottom piece, and others the sides of the box and cover. The sides are bent to shape by machinery, glued to the top and bottom respectively, and the ends fastened by small tacks.

Paper boxes are made by winding a sheet of sized paper on a cylinder, drying, and cutting the resulting tube into rings as long as the hight of a box. Circular or oval bottom and top pieces are then glued in and held firmly by the covering paper. See PAPER-BOX MACHINE.

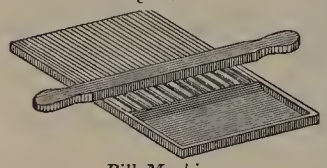
Wooden boxes are made with great rapidity by machinery. A straight grained stick is turned to the required size in a mandrel, and the cavity of the box bored out before the box is sawed off. The shoulder to receive the cover is cut by a mandrel. The cover is made in a similar manner, bored to fit the shoulder of the box. The completed boxes are cut off by saws or revolving cutters.

Pil'lion. 1. A woman's soft saddle.

2. A pad carried behind the saddle.

Pill-ma-chine'. An apparatus used by apothecaries for making pills of proper and uniform size. The ingredients, mixed to a doughy consistency with treacle or other substance, are formed into an elongated roll on the flat part of the slab by the aid of a flat stick; the roll is then divided by being pressed on the corrugated part of the slab, and the pills rounded by rolling with the fingers in sugar or other pulverized material to prevent adhesion.

Fig. 3721.

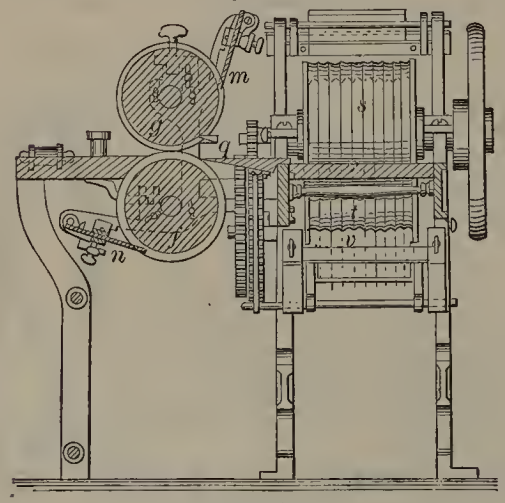


Pill-Machine.

Pills are frequently made by simply rolling the mass on a flat surface and cutting the roll into equal lengths, indicated on a graduated slip of porcelain, called a *pill-tile*.

In Fig 3722, the mass is fed between the grooved rollers *f g*, by which it is cut into cylindrical slips, which are rolled

Fig 3722.



Pill-Machine.

by hand across the table *q* to the rollers *s t* at right angles to the first pair, and revolving with unequal velocities in opposite directions. This movement, combined with the rotary motion imparted by the hand, gives a rounded form to the pills as they are cut to size by the rollers *s t*, from which they pass along an incline to the farther compartment of a receiving-box, cuttings and pills under the proper size falling into the first compartment through a grating *v*. Scrapers *m n* are attached for cleaning the rollers.

Pil'low. 1. (*Machinery.*) *a*. The rest or bearing (*a*) of a gudgeon. A *brass;* usually, however, of bronze (copper, 96 to 108; tin, 11) and not brass (copper and zinc).

Other materials have been used:—

BABBITT-METAL (which see).

Hard cast-iron.

Soap-stone.

Unseasoned green thorn-wood.

Box-wood.

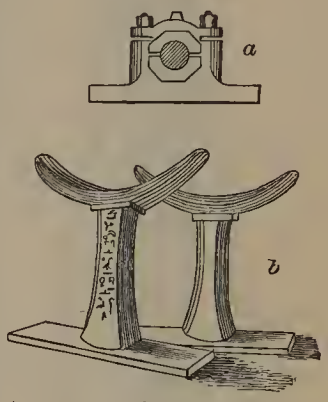
Green oak soaked in oil.

Compressed paper.

See PILLOW-BLOCK.

b. The socket of a pivot. An *ink* or *step*.

Fig. 3723.



Pillows.

2. (*Shipbuilding.*) A block of wood on which the inner end of the bowsprit rests.

3. (*Fabric.*) A kind of fustian having a four-leaved twill.

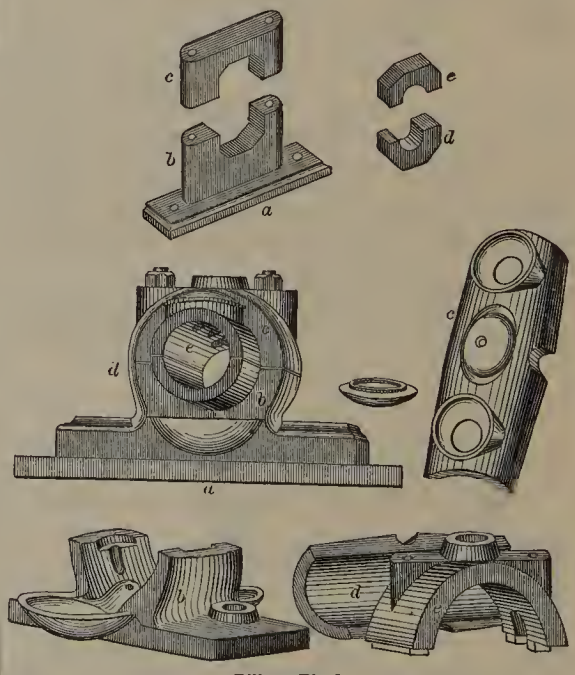
4. A cushion for the head.

The ancient Egyptians used a head-rest for a pillow (*b*), very similar to that now used in China and called a "head-stool," or rather by its equivalent in Chinese. It *looks* uncomfortable, but no doubt was preferred to our kind of pillow in a hot climate.

These Egyptian head-rests are mentioned by Porphyry. They were made of wood or alabaster. They are still used in China, Japan, Abyssinia, Ashantee, and Otaheite. Wood, stone, and earthenware are the modern as they were the ancient materials. They are from $4\frac{1}{2}$ to 10 inches high.

Many of them are preserved in the British Museum. One of wood, $6\frac{1}{4}$ inches high, and inscribed with the name and titles of Mas-khar-haô. Another of arragonite, $6\frac{7}{8}$ inches high, with a fluted column, and the name and titles of Atai in front.

Fig. 3724.



Pillow-Block.

a, base. *b*, pedestal. *c*, pedestal-cover. *d*, pillow. *e*, cap.

Others might be cited. It appears to have been a regular piece of household furniture.

The Egyptians were not ignorant of the use of soft pillows. A cushion with a linen cover and filled with the feathers of water-fowl is preserved in the British Museum.

Michal, when she sought to save her husband David from the fury of her father Saul, took an image and laid it in the bed, pillowing its head upon a bolster of goat's hair covered with a cloth.

Cushions and pillows are common in the East, formed of sheep's fleeces or goat-skins stuffed with cotton.

Pil'low-block. (*Machinery.*) An iron cradle or bearing to hold the *boxes* or *brasses* which form a journal-bearing for a shaft or roller.

Pil'low-lace. A lace made with bobbins or pirns upon a pillow. *Bobbin-lace.*

It was originally made of silk or thread woven into a net with hexagonal or octagonal meshes. Afterward, it was ornamented with a thicker thread called *gimp*, so interwoven with the meshes as to form flowers and curved designs. The pillow is hard stuffed and covered with parchment, on which the design is drawn. To form the meshes, pins are stuck into the cushion and the threads woven or twisted round them. The pattern on the parchment indicates the spots for the insertion of the pins, and also shows the places for the gimp, which is interwoven with the fine threads of the fabric. The work is begun at the upper side of the cushion by tying the threads together in pairs, each pair being attached to a pin. The threads are twisted and crossed and secured by the pins, which determine the meshes.

Pill-tile. A corrugated metallic slip for rolling pills on, to divide them accurately.

Pi-lon'-mill. A stamp-mill. The term is more particularly applied to the mill for incorporating the ingredients of gunpowder.

Pi'lot. The *cow-catcher*, or frame in front of an engine to push obstructions from the rails.

Pi'lot-cloth. (*Fabric.*) A heavy indigo-blue woolen cloth for overcoats and seamen's wear.

Pi'lot-en'gine. A locomotive sent in advance of a train, as a precaution.

Pil-u'li-er. (*Pharmacy.*) *a.* An instrument for rolling and dividing pills.

b. An earthen pot for pills.

Pi'lum. (*Pharmacy.*) A wooden, iron, bell-metal, marble, agate, porcelain, or glass instrument for triturating substances in a mortar. A *pestle.*

Pin. 1. A small piece of headed and pointed wire used as a dress fastening.

The pins used by the ladies of ancient Egypt were usually of bronze; more expensive ones were of silver or gold.

A collection of twenty-five bronze pins from the subterranean vaults of Thebes are in the Museum of the Louvre. A number are also in the Abbott Collection, New York City.

Some of the ancient Egyptian pins are 7 or 8 inches long, and have large golden heads or a band of gold at the upper end, these latter being probably used as hair-pins.

The ancient Mexicans also used pins, but generally employed the thorns on the agave as a substitute.

The pins mentioned in the Bible were those of metal for fastening the hanging around the court of the temple, and were like tent-pins; and others of wood, mentioned by Ezekiel, which were in fact wooden pegs driven into a wall to hang clothes upon.

The Roman pins had round, square, perforated, or ornamented heads; were usually of bronze; were from 1½ to 8 inches long, and were sometimes of wood, ivory, or bone. Hair-pins were common for holding up the knot of braided hair.

Before the invention of pins there were many pretty and ingenious devices for fastening the dresses and ornaments of both sexes, such as ribbons, loop-holes, laces with pearls and tags, clasps, hooks and eyes, and skewers made of gold, silver, and brass. From the latter pins were derived, being only miniature skewers. The first mention of brass pins in the English statutes is in 1483, when their importation was prohibited. An act of Henry VIII., A. D. 1543, indicates the clumsy things they were: "No person shall put to sale any pinnes, but only such as shall be double-headed, and have the heads soldered fast to the shank of the pinne, well smoothed, the shank well shaven, the point well and round filed, canted and sharpened."

The mode of making them was much improved about 1560.

Catherine Howard, queen of Henry VIII., it is said, used brass pins brought from France.

Before the introduction of Wright's pin-making machine, 1824, the following was the process: Brass wire was straightened by drawing it between pins set in zigzag order on a bench, and was then cut into lengths for six pins. These were taken a number at a time, and pointed at one end by grinding on a coarse and a fine grindstone. A length for a pin was then cut from each wire, and the process was repeated till the pieces of wire were used up. The heads were made from pieces of a fine wire coiled around a mandrel, which was then slipped out of the coil. Two convolutions were cut off for each head, and were then annealed. These bicoils were put in a tray before little boys, who fastened them on to the pins by a foot-worked hammer and an anvil. The pins were then cleansed by boiling in sour beer, wine lees, or tartar, and tinned by being laid in alternate strata with grain tin and boiled; washed, winnowed with a fan, and finally inserted by hand in the papers.

Of late years iron wire has been largely substituted for brass in the pin manufacture, making a cheaper though less enduring article.

In Wright's patent, the main shaft of the machine gives motion in its rotation to a number of sliders, levers, and wheels, which work the different parts of the apparatus. A slider pushes forward pinchers, which draw wire from a reel at every rotation of the shaft, and advance such a length of wire as will produce one pin. A die cuts off this length by the descent of its upper jaw, and the latter then opens a carrier, which takes on the wire to the pointing apparatus. Here it is received by a revolving holder, while a bevel-edged file-wheel, rapidly turning, gives to the wire its first rough point. It proceeds immediately by a second carrier to a finer file-wheel, by which the process of pointing is finished. A third carrier transfers the pin to the first heading-die, and by the advance of a steel punch one end of the pin-wire is forced into a recess, whereby the head is partially produced. A fourth carrier removes the pin to a second die, where the heading is completed. When the heading-bar retires, a forked lever draws the pin from the die and drops it into a receptacle beneath. This completes the production of the pin so far as the machine is concerned, but it has yet to be whitened, polished, sorted, and stuck.

The first process is effected by rolling them in a rotating barrel containing sawdust; after removal from this they are placed in kettles, between perforated plates of tin, which form alternate layers with the pins. Very dilute nitric acid is added, and boiled for three hours, when the pins, covered with an almost infinitely thin coating of tin, are withdrawn, being then of a dull whitish hue. They are again rolled in a barrel with hot sawdust to give them the final polish. The perfect and imperfect pins are then separated by a series of belts having a combined horizontal and oscillating movement, which retain the defective ones on the belts until arriving at their ends, while those of perfect form, having no hold on the belts, are shaken off into a receptacle below.

To separate those of different sizes, they are transferred to an inclined plane, down which they slide to a horizontally revolving wheel provided with sets of steel fingers, each of which is adapted to grasp pins of a particular length and distribute them into separate receptacles.

Having been sorted, they are next stuck into the papers. This may be effected by the hand-machine or the power-machine.

In the former the pins are placed in a hopper, and are caught by their heads between conductors which convey them through a goose-neck to a slide having as many notches as there are to be pins in a row; when these are filled the slide is withdrawn, a crimper seizes the paper and holds it while the pins are driven through.

In the power sticking-machine the pins are placed upon a slowly revolving table, from which they drop into a revolving cylinder having longitudinal ribs, which transfer them to an endless chain, the links of which are notched so as to receive the pins, which hang by their heads and are carried forward to a gate, where they are driven into the paper, which is simultaneously crimped and held to receive them.

Pins of peculiar forms and sizes are made for specific purposes. Among these may be mentioned *diaper*, *dress*, *cloak*, *scarf*, *shawl* pins, whose names indicate their duty.

Besides these are others used in the toilet or about the work-table, such as the *breast*-pin, *hair*-pin, *sewing*-pin, etc.

2. A peg or bolt of wood or metal, having many uses. Among these may be cited, —

a. A *bedstead*-pin, projecting from the rail to hold the cord.

b. A *belaying*-pin, for coiling ropes upon.

c. A *coupling*-pin, uniting the draw-heads of adjacent railway-cars.

d. A *tent*-pin, to which the ropes are fastened.

e. A *treenail.*

3. The axis of a sheave.

An axis of a joint, as of the gimbal or compass-joint.

4. A *clothes*-pin, to grip a garment to a clothes-line.

5. The bull's-eye of a target.

6. The peg of a stringed instrument on which it is wound in tightening.

7. The *linch*-pin of an axle.

8. The turning axis of a capstan, crane, windlass, etc.

9. (*Locksmithing.*) The part of a key-stem which enters the lock. See KEY.

10. (*Joinery.*) The smaller member of a dovetail which fits into the *socket* or receiving portion.

11. To swage by striking with the *peen* of a hammer; as splaying an edge of an iron hoop to give it the flare corresponding to that of the cask.

Pi'na. (*Spanish.*) The pile of wedges or *bricks* of hard silver amalgam placed under a *capellina* and subjected to heat, for the expulsion of the mercury. See AMALGAMATOR.

Pin'cer. See PINCHERS.

Pinch-bar. A lever with a fulcrum-foot and projecting snout; applied beneath a heavy body to move it by successive small raising and shiftings.

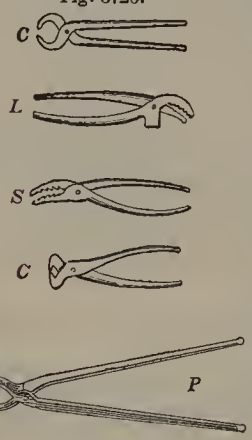
Fig. 3725.

Pinch-Bar.

Pinch'beck. A brass for cheap jewelry: copper, 5; zinc, 1. Named after the introducer. See ALLOY.

Pinch'ers. An instrument having two handles and two grasping jaws, formed of two pieces pivoted together. Pinchers are adapted for special work, such as drawing nails, for shoemakers' use (see cut).

Fig. 3726.



Pinchers.

C, common pinchers.
L, lasting-pinchers.
S, shoemakers' pinchers.
C, cutting-pinchers.
P, pinching-tongs for making glass *drops* for chandeliers.

Pinch'ing. A term applied to moving a heavy object, such as a gun, mortar, log, or bed-plate, by small heaves of the handspike, which describes arcs of a circle nearly horizontally. See PINCH-BAR.

Pinch'ing-bar. A crow-bar for moving an object by successive short hitches. A *pinch-bar*.

Pinch'ing-nut. A *jam-nut* screwed down upon another nut, to hold it in position. A *check-nut* or *lock-nut*. See NUT-LOCK.

Pinch'ing-pin. (*Steam.*) A portion of the devices by which a slide-valve is packed or tightened upon its seat.

Pinch'ing-tongs. (*Glass-making.*) Used for making chandelier-drops, etc. Each jaw of the tongs carries a die, between which a lump of glass heated to plasticity is compressed; a wire between the jaws makes the hole by which the drop is suspended. It is afterward cut and polished on a leaden lap. See PINCHERS.

Pin-cop. (*Spinning.*) A yarn, roll-shaped like a pear, used for the weft in power-looms.

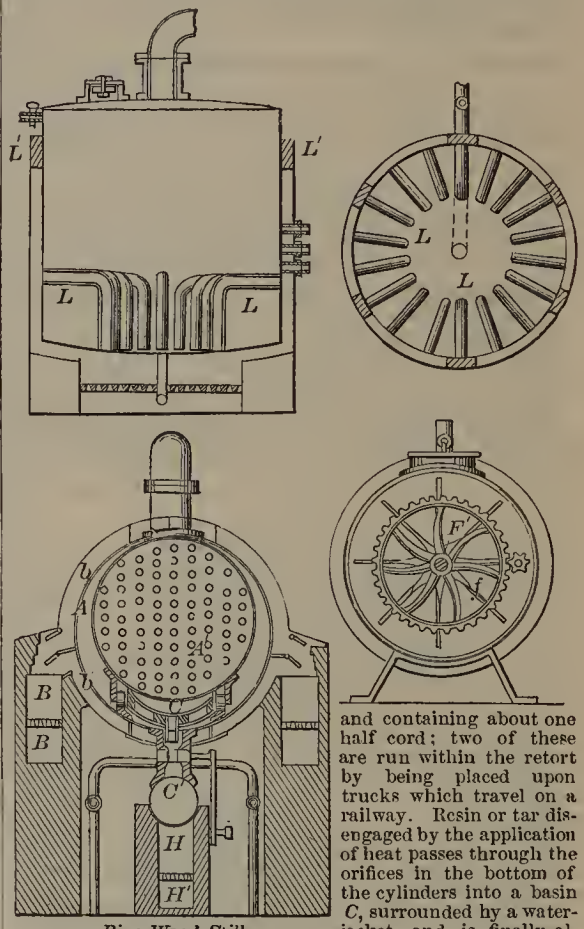
Pin-drill. A drill for countersinking. The central portion is a plug, which fits in the hole previously bored, and around it is an annular cutting portion, which makes the depression for the head of a bolt, rivet, or screw. In a certain modification, the drill is steadied in position by a center-pin, which bears in a hole made by a center-punch retiring into the stock as the drill advances into its work.

Pine-leaf Fab'ric. This is described in the "Journal of the Franklin Institute," 1852, page 412 *et seq.* The green leaves are used in preference at Breslau for making this pine-tree wool, which was extensively used from 1842 for mattresses, coverlets, etc. Five hundred of these coverlets were purchased for the hospital of Vienna in the former year, and shortly afterward at other places. It was particularly useful as stuffing for beds and for upholstering, as it was offensive to insect vermin. The leaves are treated by heat and chemical reagents to separate the fibers and remove the resin. The invention is credited to M. Pannewitz. "Bib. Univ. de Genevi," June, 1852, page 165. See also English patent, No. 1002, 1853. See also Belgian patent, "Genie Industriel," Paris, 1864, page 104, where the process is fully described.

Pine-wood Still. An apparatus for obtaining tar, resin, and the volatile products of pine-wood by distillation.

Mellen's consists (1) of a cylindrical retort *A* surrounded by flues *b b'*, and heated by a furnace *B B* on each side; the wood is placed in cylinders *A'* perforated at their heads and bottoms,

Fig. 3727.



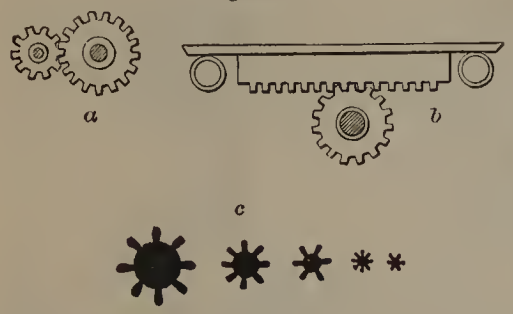
Pine-Wood Still.

and containing about one half cord; two of these are run within the retort by being placed upon trucks which travel on a railway. Resin or tar disengaged by the application of heat passes through the orifices in the bottom of the cylinders into a basin *C*, surrounded by a water-jacket, and is finally allowed to flow into the pitch-chamber *C'*, heated by the furnace *H H'*. The volatile products, turpentine or pyroligneous acid, pass over into a condenser, from whence they are drawn off into a rotating agitator *F' f*, where they are mingled with purifying agents. This process complete, they are transferred to the still *L L L' L'*, which is surrounded by a fire-jacket, and has radial flues in its lower part; in this they undergo the final distillation.

Pine-wool. Fiber obtained from the leaves of *Pinus sylvestris*, from which *vegetable flannel* is made. See PINE-LEAF FABRIC.

Pin'ion. Of two cog-wheels in gear, the lesser is called the *pinion*. It may be *spur*, *bevel*, *miter*, etc. The pinions of watches are made from pinion-

Fig. 3728.



Pinions.

a, pinion and spur wheel; *b*, pinion and rack; *c*, pinion-wire.

wire, turned down at the parts which are not destined to mesh with the coäcting wheel.

Pin'ion-file. (*Watchmaking.*) A knife-file employed by watchmakers.

Pin'ion-gage. (*Watchmaking.*) A fine calipers.

Pin'ion-wire. (*Metal-working.*) Wire formed into the shape and size required for the pinions of clocks and watches; it is drawn in the same manner as round wire through plates whose holes correspond in section to the shape of the wire. See PINION.

Pink. (*Nautical.*) A ship with a very narrow stern; used in the Mediterranean.

Pink'ing-i'ron. A cutting-tool for scalloping the edge of ribbons, flounces, paper for coffin trimmings, etc.

Pink-salt. (*Dyeing.*) Ammonia combined with perchloride of tin, used in calico-printing.

Pink-stern. (*Nautical.*) Said of a vessel with a very narrow stern.

Pin-lock. One of which the bolt is a round protruding pin, as in some forms of locks.

Pin'nace. *a.* A man-of-war's boat, next in size to the launch; it is carvel-built, usually 28 to 32 feet long, has a beam .29 to .25 of its length, and is rowed by 6 or 8 oars.

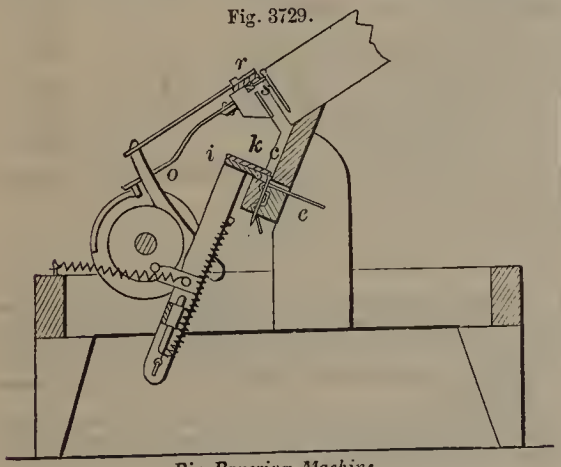
b. A small schooner-rigged vessel provided with oars or sweeps; vessels of this kind of 60 to 80 tons burden were formerly employed by the French for coast defense, and carried one long 24-pounder and 100 men.

Pin'na-cle. (*Architecture.*) An ornament placed on the top of a buttress as a termination to an angle or gable of a house, church, or tower; also a summit or lofty apex.

Pin'ning-in. (*Masonry.*) The filling in of the joints of stone walling with spalls of stone.

Pin-pa'per-ing Ma-chine'. In Fowler's machine the pins, fed from an inclined table, are separated and arranged into a row by reciprocation of the stop-bar *r* and toothed cut-off *s*; falling into grooves *c*, they are conducted to the spring door *k*, which is swung open by the vibratory movement of the rake *i* to the crimper, and forced through the paper by a downward motion of the rake.

Fig. 3729.



Pin-Papering Machine.

Pin-rack. (*Nautical.*) A frame placed on the deck of a vessel, and containing sheaves around which ropes may be worked, and belaying-pins around which they may be secured.

Pin-tail. The iron pin in the axletree of a limber, to which the trail-eye of the gun-carriage is attached for travel. *Pintle.*

Pin'tle. A pivot-pin, such as that of a hinge.

a. The *hook* portion of a rudder hinge which is driven into the stern-post and receives the *brace* of the rudder. 1, *pintle;* 2, *brace* (Fig. 3730) with *jaws* which clasp the rudder.

A dumb-pintle at bottom is the step of the rudder on the framing. The rudder is *wood-locked* above to prevent unshipping. See Fig. 3730.

b. A bolt to prevent the recoil of a cannon.

c. The bolt on which a chassis oscillates in traversing.

d. A plate with projections of the nature of dowel-pins placed between the lengths which constitute an upright post.

e. A king-bolt of a limber or wagon.

f. The pin on which the leaves of a hinge vibrate.

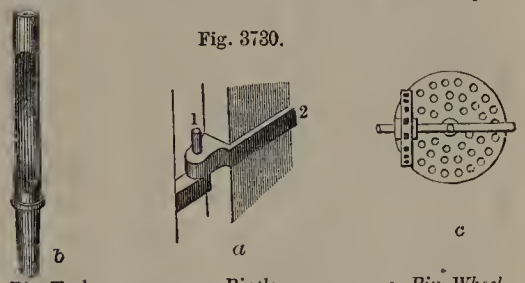
Pin-tool. A tubular cutter (*b*, Fig. 3730) for making pins for sash, blind, and door makers. The stuff is got out in the square, and is cut round by forcing the tool against it in the direction of the grain. The stuff is pine, poplar, or other soft wood. Hard-wood pins for *dowels*, etc., are turned. See ROD, PIN, and DOWEL.

Pin-vise. (*Clock-making.*) A hand-vise for grasping small arbors and pins.

Pin-wheel. A contrate wheel in which the cogs are pins set into the disk.

The disk-wheel *c* has three concentric rows of pins, either of which may be made to engage the mortise-wheel, according to the speed required.

Fig. 3730.



b, *Pin-Tool.* *a*, *Pintle.* *c*, *Pin-Wheel.*

Pipe. 1. A tube for conveyance of water, air, or other fluid.

Clay pipes were used by the Romans for aqueducts, drains, hollow walls, and domes. The pipes had contracted ends to enter the sockets of the adjoining ones. In the thermæ of Antoninus the pipes were cylindrical; in the baths of Titus, square; in the fountain of Egeria, conical and fitting into each other.

Pipes are now made of cast and wrought iron, copper, lead, tin-lined lead, various kinds of clay and concretes, glass; wood treated with antiseptics or with resins, paraffine, etc., to render it water-proof; folds or plies of sealeboard or paper treated as stated.

"Through pipes of metal, water both warm and cold, to suit the season of the year, was delivered into baths of marble." Description of the palace of Abderrahman III. at Zehra, Spain, about A. D. 757. Talk about a house "with all the modern conveniences"!

Rule for the Computation of the Weights of Cast-Iron Pipes (HORATIO ALLEN).

To the inner diameter of the pipe add the thickness of the pipe in inches, and multiply the sum by ten times the thickness, and the product will give the weight in pounds per foot.

Weight of Riveted Iron and Copper Pipes, from 5 to 30 Inches in Diameter, from 1/8 to 5/16 in Thickness, 1 Foot in Length (HASWELL)

Diameter.	Thickness.	Iron.	Copper.	Diameter.	Thickness.	Iron.	Copper.
Inch.	Inch.	Lbs.	Lbs.	Inch.	Inch	Lbs.	Lbs.
5	1/8	7 12	8.14	9	1/4	25.01	28.58
	3/16	10.68	12.21		1/4	26.33	30.09
	1/4	14.25	16.28	10	1/4	27 75	31.71
5 1/2	1/8	7.78	8.89	10 1/2	1/4	29.19	33 22
	3/16	11.66	13.33	11	1/4	30.49	34.85
	1/4	15.56	17.78	12	1/4	33.13	37.86
6	1/8	8.44	9.64	13	1/4	35.88	41
	3/16	12.65	14.46	14	1/4	38.52	44.02
	1/4	16.88	19.29	15	1/4	41.26	47.15
6 1/2	1/8	9.1	10.4		5/16	51.57	58.94
	3/16	13.65	15.6	16	1/4	43.9	50.17
	1/4	18.2	20.8		5/16	54.87	62.71
7	1/8	9.78	11.18	17	1/4	46.53	53.18
	3/16	14.68	16.78		5/16	58 17	66.48
	1/4	19.57	22.37	18	1/4	49.17	56.2
7 1/2	1/8	10 49	11.99		5/16	61.47	70 25
	3/16	15.73	17.98	20	5/16	68 07	77 79
	1/4	20.89	23 87	24	5/16	81.33	92.95
8	3/16	16.7	19.08	25	5/16	84.57	96.65
	1/4	22.26	25.44	28	5/16	94.56	107.95
8 1/2	1/4	23.59	26.96	30	5/16	101.14	115 59

The above weights include the laps of the sheets for riveting and calking.

The weights of the rivets are not added, as the number per lineal foot of pipe depends upon the distance they are placed apart, and their diameter and length upon the thickness of the metal of the pipe.

Table of Standard Dimensions of Wrought-Iron welded Tubes (HASWELL).

Nominal diam.	External diam.	Thickness.	Internal diam.	Internal circum.	External circum.	Length of pipe per sq. foot of internal surface.	Length of pipe per sq. foot of external surface.	Internal area.	Weight per foot.	No. of threads per inch of screw.
In	Ins.	Ins.	Ins.	Ins.	Ins.	Feet.	Feet.	Ins.	Lbs.	
1/8	.40	.068	.27	.85	1.27	14.15	9.44	.057	.24	27
1/4	.54	.088	.36	1.14	1.7	10.5	7.075	.104	.42	18
3/8	.67	.091	.49	1.55	2.12	7.67	5.657	.192	.56	13
1/2	.84	.109	.62	1.96	2.65	6.13	4.502	.305	.84	14
3/4	1.05	.113	.82	2 59	3.3	4.64	3.637	.533	1.13	14
1	1.31	.134	1.05	3 29	4.13	3.66	2.903	.863	1.67	11 1/2
1 1/4	1.66	.14	1 38	4.33	5 21	2.77	2.301	1.496	2.26	11 1/2
1 1/2	1 9	.145	1.61	5.06	5.97	2.37	2.01	2.038	2.69	11 1/2
2	2.37	.154	2.07	6.49	7.46	1.85	1.611	3.355	3.67	11 1/2
2 1/2	2.87	.204	2.47	7.75	9 03	1.55	1.328	4 783	5.77	8
3	3.5	.217	3 07	9.64	11	1.24	1.091	7.388	7.55	8
3 1/2	4	.226	3.55	11.15	12 57	1.08	0.955	9.887	9.05	8
4	4.5	237	4 07	12.69	14.14	.95	0.849	12.73	10.73	8
4 1/2	5	.247	4.51	14.15	15.71	.85	0.765	15.939	12.49	8
5	5.56	259	5.04	15.85	17.47	.78	0.629	19.99	14.56	8
6	6.62	.28	6.06	19.05	20 81	.63	0 577	28.889	18 77	8
7	7.62	.301	7 02	22.06	23.95	.54	0.505	38.737	23.41	8
8	8.62	.322	7.98	25 08	27.1	.48	0.444	50.039	28.35	8
9	9.69	.344	9	28.28	30.43	.42	0.394	63 633	34.08	8
10	10.75	.366	10.02	31.47	33.77	.38	0 355	78.838	40.64	8

The following list includes pipes known by their material, mode of manufacture, purpose, construction, or form; also machines and tools for making or using them. See under the following heads: —

Blast-pipe.
Burras-pipe.
Chain-locker pipe.
Clay-pipe.
Cock.
Concrete-pipe.
Coupling.
Drip-pipe.
Earthen pipe.
Eduction-pipe.
Exhaust-pipe.
Faucet.
Feed-pipe.
Flange-pipe.
Flute-pipe.
Gas-pipe.
Hawse-pipe.
Heating-pipe.
Iron pipe.
Laminated pipe.
Lead pipe.
Locomotive smoke-pipe.
Main.
Mouth-pipe.
Organ-pipe.
Pandean-pipe.
Pipe clamp.
Pipe-clearer.
Pipe-coupling.
Pipe-cutter.
Pipe-grab.
Pipe-joint.
Pipe-molding.
Pipe-prover.
Pipe-socketing machine.
Pipe-threader.
Pipe-tongs.
Pipette.
Pipe-valve.
Pipe-vein.
Pipe-vise.
Pipe-wrench.
Pitch-pipe.
Reed-pipe.
Screwed tubes.
Service-pipe.
Socket-pipe.
Smoke-pipe.
Smoking-pipe.
Stand-pipe.
Steam-pipe.
Stone pipe.
Sub-aqueous tube.
Suction-pipe.
Tapping water-pipe.
Thimble-joint.
Tile-machine.
Tin-lined lead-pipe.
Tobacco-pipe.
Tube-drawing.
Tube-welding.
Union.
Valve.
Water-pipe.
Welded tube.
Wooden pipe.
Wrought-iron pipe.

2. (*Music.*) A tube of wood or metal used in wind-instruments, as the *Pandean*-pipes, the *organ*, etc.

Many straight tubular instruments have specific names, as the *flute*, *flageolet*, *clarinet*, etc. See list under MUSICAL INSTRUMENTS. The pipe is among the most ancient of wind-instruments. See FLUTE.

Ptolemy, in his "Harmonics," explains how the acuteness and graveness of notes is produced: "In strings and pipes, other things remaining the same, those which are stopped at a smaller distance from the bridge give the most acute note; and in pipes, those notes which come through holes nearest to the mouth-hole are most acute."

The ancient pipe (*tibia*) had various forms; was made of reed, of boxwood bored with a gimlet (*terebrato buxo*), or of bone; that of asses preferred by the Greeks. It is suspected that the clarinet, flageolet, and flute forms were all known and used; the bagpipe also. One form of single pipe had a mouth-piece set in at right angles. The Pandean-pipe or syrinx is very ancient. The double pipe was rather a pair of pipes, and was used for air and accompaniment. They were distinct and of different pitch, say bass and treble; known as *tibia dextra*, *tibia sinistra*, *male* and *female*; low and high.

The mouth-pieces of the musical pipes were made of a reed growing in a lake above Celænæ in Phrygia. (STRABO.) Pliny also mentions it. The double pipe was a very common instrument with the Egyptians and Greeks, and still survives as the *zumâra* of modern Egypt.

Among the pipe-instruments of the Japanese we recognize the analogues of the Pandean-pipes, the flute, and the flageolet.

Organ-pipes are of two kinds: —

1. The *flute-pipe* or *mouth-pipe*, which has a lip to cut the wind escaping through an orifice in a diaphragm. See MOUTH-PIPE.

2. The *reed-pipe*, wherein the sound is first produced by the vibration of a metallic tongue. See REED-PIPE.

Mouth-pipes are technically said to have *bodies*, and reed-pipes *tubes*.

The *pitch* of the note depends upon the length of the pipe above or beyond the *mouth*. The longer the pipe, the graver the tone, and conversely.

Doubling the length of the pipe gives a note an octave lower. Halving the length of a pipe gives a note an octave higher. Stopping the end of a pipe lowers the pitch one octave, the effect being to double the length, as the wind is obliged to return on its tracks and find an exit at the mouth, after having twice passed the length of the pipe.

"Tomlinson on Acoustics" gives the following table: —

	Length of open pipe in feet.	Vibrations per second.
The lowest audible note, C below, is produced by	32	32
The lowest C of a grand piano is produced by	16	64
The lowest C of the violoncello is produced by	8	128
The tenor C is produced by	4	256
The middle C, the note of the C clef, is produced by	2	512
C on the third space in the treble clef is produced by	1	1,024
C in alt is produced by	1/2	2,048

The length of a pipe for a given octave being 1, the lengths for the intervals will be as follows: —

The upper C	1/2	F	3/4
B	8/15	E	4/5
A	3/5	D	8/9
G	2/3	The lower C	1

The quality of the tone, the *timbre*, depends on the size of the pipe, the material of which it is made, the form of the body or tube, and the nature of the construction, whether *reed* or *mouth*.

Different woods give tones differing in respect to mellowness and clearness.

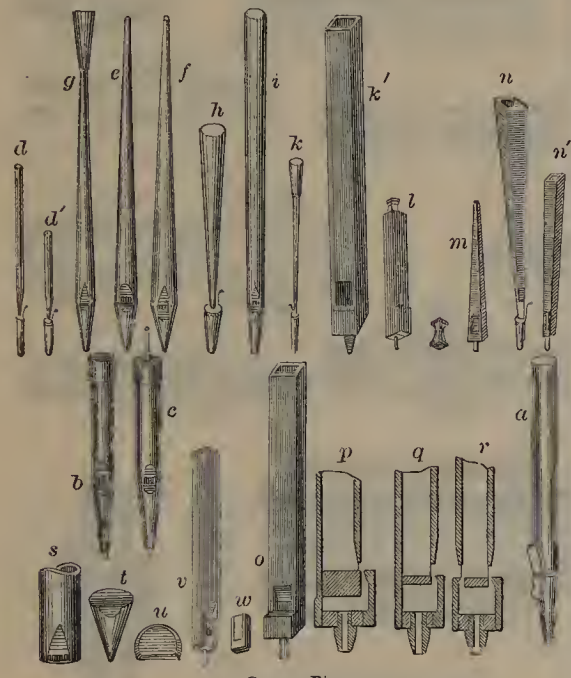
It has been noticed, that while the sides of a wooden pipe vibrate violently in the process of *speaking*, the front and back remain perfectly quiet.

The thickuess of the material, its toughness aud elasticity, exert an influeuce on the tone of metallic pipes without at all affecting their pitch. The size and proportions of the mouth also affect the quality of the sound emitted by the pipe. The standard proportions are, for the width of the mouth one fourth the diameter of the pipe, and for its depth one tenth of the same diameter; but these are varied to produce different effects. A wide aud high mouth produces a round, powerful tone; a narrow mouth a sharper tone; and a narrow and low mouth a delicate tone. If, however, the upper lip be too high, the pipe will either sound slowly or not at all; and if the mouth be too narrow, it will speak an octave above the correct note.

Pipes are either round or rectangular in cross-section, and these two classes are divided into several varieties. The principal kinds of round-bodied pipes are cylindrical, conical, conical surmounted by a bell, inverted cone, inverted cone surmounted by a bell. Cylindrical pipes are either *open* (*a*, Fig. 3731), *stopped*, or half stopped, the first being more numerous iu all organs. The stops called *open diapason*, *principal*, *fifteenth*, and *mixture*, among others, are usually composed of pipes of this shape.

Stopped cyliudrical pipes (*b*) are closed at top by a metallic

Fig. 3731.



Organ-Pipes.

cap. They are rare in English, but quite common in German organs, under the names of *gedacht* and *quintation*.

Half-stopped pipes (*c*) have a perforated cap, in which a small tube is inserted.

In certain stops cylindrical pipes perforated with one or two holes near the top or about midway of the body are employed.

Though usually of metal, it is common in Germany to make cylindrical pipes of wood; these produce a very superior tone.

Some soft-toned *reed*-stops, as the *clarinet* (*d*) and *vox humana* (*d'*), are cylindrical.

Conical pipes vary considerably in taper. *e* represents the German *spitz flöte*, which tapers to about one half its greatest diameter. The *gemshorn* (*f*) has a still greater diminution at the top Conical pipes with a bell at top (*g*) are used in the *viol de gamba* stop of English organs.

Inverted conical pipes (*h i*) are largely employed in most organs, the greater portion of those of the reed-stops having this general form. Flue-pipes are also in some cases made in this way. Inverted cones with a bell (*k*) are employed for the *hautboy* and its octave.

Four-sided pipes are common in most organs; they are either *open* (*k'*) or partially or entirely *stopped*. Open pipes of this class are frequently introduced in the bass of the *dulciana* and *open diapason*. Some stops, as the *claribella*, etc., are exclusively composed of open pipes.

Four-sided *stopped* pipes (*l*) are closed at the upper end with a *stopper* fitting within the tube and provided with a handle. In half-stopped pipes a perforation is made through the handle and stopper. Pipes of this kind are generally used in the treble of certain stops, the larger sizes seldom being bored.

Pyramidal pipes (*m*) are sometimes used in the bass of tops composed principally of metallic conical pipes; in some instances, entire stops are made up of them.

Inverted pyramidal pipes (*n n'*) are frequently used in the large reed-stops, 16 to 32 feet; small reed-stops, as the *bassoon*, are frequently composed of pipes of this kind.

In stopped and half-stopped wooden pipes, the stopper is covered with leather at the top and sides, to make a tight joint.

The mouth is formed by beveling off the front board (*o*), so that its lower edge constitutes the upper lip, and leaving an opening betweeu it and the cap, the upper edge of which is the under lip.

Sometimes the mouths of *block pipes* are inverted. In this arrangement, the inner surface of the front board is beveled (*p*), and the block extends as far as the outer surface of the body. *Languid* wooden pipes (*q*) have a plate or languid (Fr. *langue*, tongue) of wood substituted for the block. Large pipes are often of this kind. The *double-mouthed* pipe (*r*) has a mouth on each side placed opposite each other, producing, it is claimed, greater strength of tone.

The gravity or acuteness of the note produced, in other words, the *pitch*, depends, iu pipes of the "mouth" or "flue" class, upon their length. In the reed kind, on the contrary, it depends on the size of the mouth-piece and the vibrations of the tongue; thus, an open-flue pipe must have a body of eight feet length to produce the CC sound, while the tube of the reed-pipe may be only eighteen iuches long. Iu instruments of the accordeon class, the tube is entirely dispensed with, the note being formed by the tongue alone; the tube, however, greatly increases the strength and fullness of the sound.

An open metallic flue-pipe consists of three parts: the *body*, *foot*, and *language*, *languid*, or *languette*. The *body* (*s*) is the part above the mouth. It is formed by rolling a sheet of metal around a mandrel, the edges forming the seam being soldered together; on the front or opposite side, an indentation, the *leaf*, is formed at bottom, the lower part of which is cut away, leaving an opening, the *mouth*; the lower edge of the leaf is termed the *upper lip*. The *foot* (*t*) is an inverted cone, formed in a similar manner, and having a corresponding indentation, called the *under lip*, which conducts the wind to the mouth through an aperture at the apex of the cone. The foot also serves as a support to the pipe, for which purpose it is made of extra thickness and strength.

The *language* or *languid* (*u*) is a flat piece of strong and thick metal immediately over the top of the foot and just inside the mouth. Its front edge is straight, like those of the upper and under lips, but is placed slightly behind the latter, so as to leave a narrow opening, the *wind-way*, between. This edge is also beveled and indeuted, to direct the *sheet of wind* fairly against the upper lip.

Stopped metal pipes have a cap either tightly fitting but movable or soldered on over the body.

Half-stopped pipes have a small cylindrieal tube or chimney soldered into a hole in the center of the cap, somewhat increasing the freedom and strength of the tone. Metallic flue-pipes are frequently furnished with pieces of metal, called *ears*, projecting from each side of the mouth.

An open wood pipe (*v*) consists of the *body*, *block*, *cap*, and *foot*. The body is a rectangular tube formed of planed boards, and is usually oblong in cross-section. A nearly square pipe gives a full aud weighty tone; oue that is narrow and deep, a soft and sweet tone; while a shallow and wide pipe yields a powerful and hollow tone. The proportions vary from square to 2 by 1, or nearly so, according to the effect to be produced.

At the lower end the body is closed by the block, which is nearly divided in two by the throat; over this is fastened the cap (*w*), a piece of wood bollowed out on one side, the upper edge of which slightly recedes to form a wind-way. The pipe-foot is a rectangular or cylindrieal tube inserted through an opening in its bottom to admit wind and support the pipe.

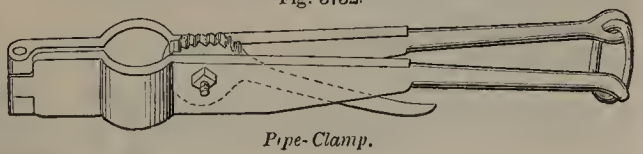
Ducce's organ at the English Exposition of 1851 was so arranged as to produce the 12 pedal notes from a single stopped pipe, 4 feet long. The notes ranged from 16 feet C, and besides the range of depth far beyond what the length of pipe would seem to justify, the pipe was made to speak several notes by openiug holes, somewhat iu the manner of the flute, clarinet, and flageolet. The valves to open and close these holes were operated by the pedal keys, and the whole octave of pedal notes thus produced from a sing'e pipe in the stool of the organist.

3. A tube with a bowl to hold tobacco, opium, or other narcotic or medicinal leaf, which is burned slowly to yield smoke. See SMOKING-PIPE.

Pipe-box. (*Vehicle.*) The box of a *hub* or *nave* which receives the *arm* or *spindle* of the axle.

Pipe-clamp. A vise or holder for a pipe. See PIPE-VISE.

Fig. 3732.



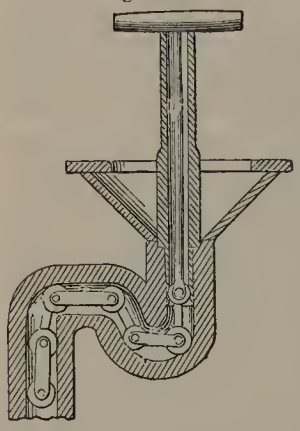
Pipe-Clamp.

The example shows a tool to hold a deep-well pipe to prevent it from slipping in while an additional length is being attached.

Pipe-clay. A white clay whose excellence depends upon its freedom from iron.

Pipe-clear'er. An implement for pushing out an obstruction from a bend in a pipe. A force-pump is usually employed, but in some cases a jointed thrusting implement is used, as in the example.

Fig. 3733.



Pipe-Clearer.

Pipe-coup'ling. A means of uniting two pipes to make their tubular portions continuous. Such couplings are usually in line, lateral connections being by angular or bent sections or by branching sections.

a b show respectively the *faucet* end and the *spigot* end of a pipe.

c shows the common mode of entering the *spigot* end of one pipe into the *faucet* end of another one, the joint being made by running lead and compacting by the cold chisel and hammer.

d has a set screw in one section bearing against a flange on the spigot section.

e is for wooden pipe. A circular metallic section has sharp flanges which enter the contacting ends of the pipes to be united.

In *f*, the parts are halved into each other by socket and tenon, and fastened by screws.

g is a view of a coupling-section having conical tubular ends which enter the ends of the pipes to be united, and which are forcibly driven upon the cones.

h has a double socket-section into which the ends of the pipe are driven and then fastened by keys.

i j are two views of a hose-coupling, in which the sections are drawn together against a packing-ring by rotation, a stud on one section traversing a spiral groove in the other.

k has sections with slots traversed by a transverse locking key.

l is a hose-coupling, in which the ends of the hose are clamped between a pair of sleeves and a double-ended coupling-section.

In *m*, a flange on the end of one pipe abuts against the end of the other pipe, inside a coupling-sleeve which screws on to a thread on one of the pipes. A packing-ring is between the abutting ends of the pipes.

n is a screw-coupling in which the parts screw together against a packing-ring.

o shows the plunger-pole used in Cornish mines. It consists of a stuffing-box, gland, and bolts.

p is the pipe-coupling used in the Westinghouse air-brake for coupling adjacent cars. When the cars are uncoupled, the valves seat themselves instantly; when the cars are coupled, the air-way is open.

q is a flexible coupling shown in three views.

The Croton aqueduct pipe, which carries the water across the Harlem River, is 850 feet long, and is cast in 8-foot lengths, which are united by hollow ball-and-socket joints. *r* is formed by providing one end of the pipes with a concave flange, which receives the conjoining pipe-end, having annular ribs upon it. The space between the pipe-end and the flange is packed with lead. The joint is thus rendered secure without screw-bolts.

The method adopted by Mr. Ward for laying the pipes was as follows: A large open boat was provided, in which was carried a supply of pipes and melted lead. At the stern a small supporting frame was placed. The pipes were jointed together in the boat, and, as fast as completed, pushed out over the stern into the water, thus forming a flexible string of pipes, which sank and rested upon the river-bottom as the boat progressed. The depth of water in the Harlem River where the pipe lies is 40 feet.

The water-mains of London are or were united by cylindrical, turned joints, a little whiting or tallow being used to close the joint perfectly and permitting expansion and contraction of the pipe with changes in the temperature of the water. See also HOSE-COUPLING.

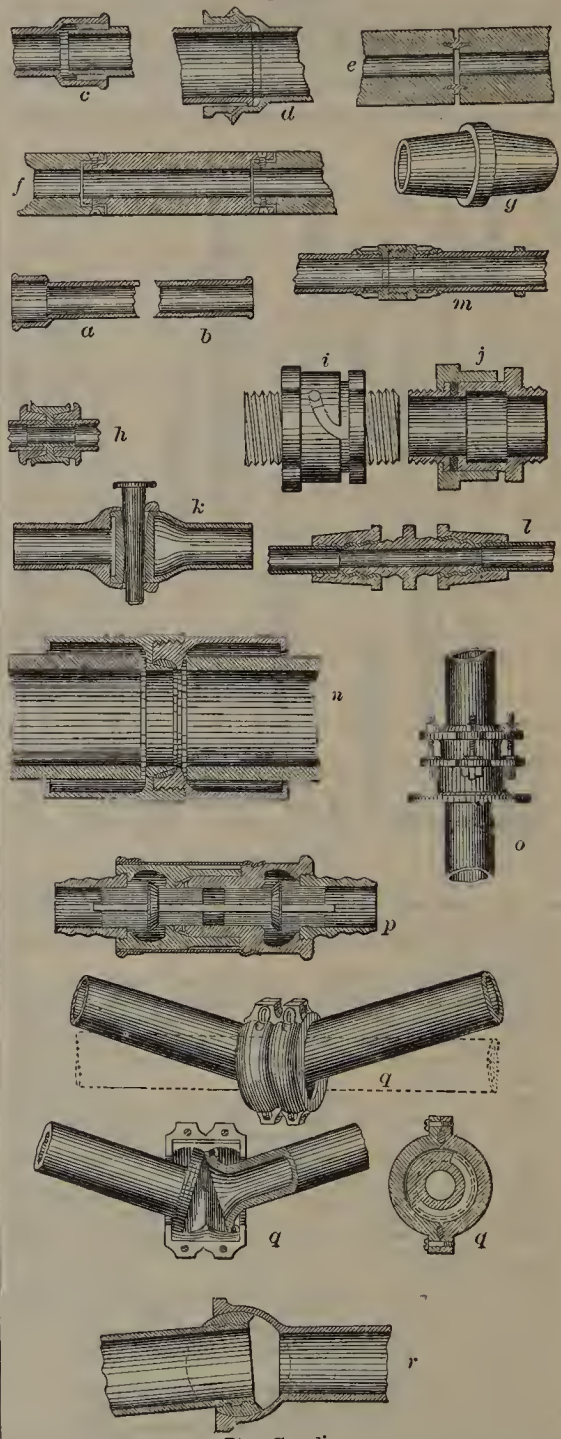
There are several forms of lead-joints in which the spigot end is forced against a cast leaden gasket so as to crush the latter and form a tight joint.

Machines are also made for connecting pipes; O'Neill's twisting-jack, for instance. In this case the contacting ends of the sections or lengths forming the water or gas main have lugs and inclined faces which pass each other and then by a twisting action are made to draw longitudinally and compress the leaden gasket, which makes the joint air and water tight.

Pipe-cut'ter. A tool for cutting off gas or water pipes. It has a hook which passes beneath the pipe and forms a rest while the cutting chisel or disk is driven down the pipe, around which the implement is then revolved.

In Fig. 3735, a sharpened disk within a block is fastened to the end of the screw-rod, and the pipe, being clamped between the disk and the hook, is cut by turning the instrument around the pipe.

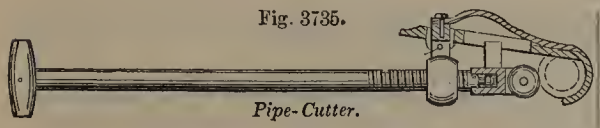
Fig. 3734.



Pipe-Couplings.

In Fig. 3736, the tube and its bushing are made to encircle the pipe, and the cutter is forced into the side of the pipe by turning the screw. The pipe is then severed by turning the instrument around upon it.

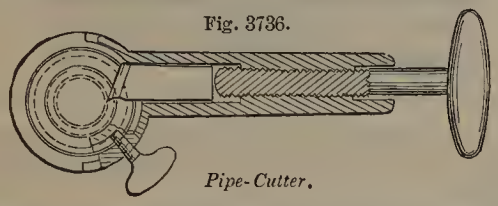
Fig. 3735.



Pipe-Cutter.

In Fig. 3737, the movable jaw is hinged to a nut which traverses the threaded shank, and operates in opposition either to the socket end of the shank or to a cutter inserted therein.

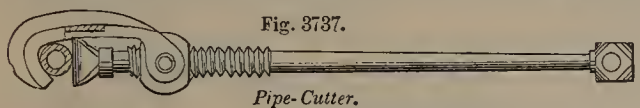
Fig. 3736.



Pipe-Cutter.

Fig. 3738 is a tool with three revolving cutters set in such a relative manner that two of the cutters are in a stationary part

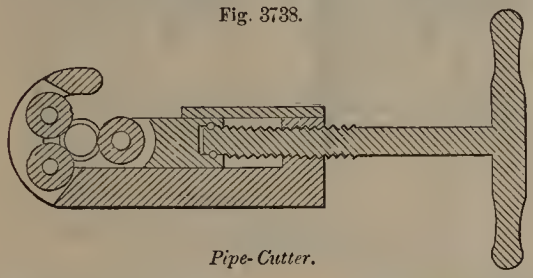
Fig. 3737.



Pipe-Cutter.

or body of the tool, and the adjustable cutter is held by a movable part or stock of wrought-iron, which is held by a screw. See also PIPE-CUTTER and THREADER, Fig. 3744.

Fig. 3738.

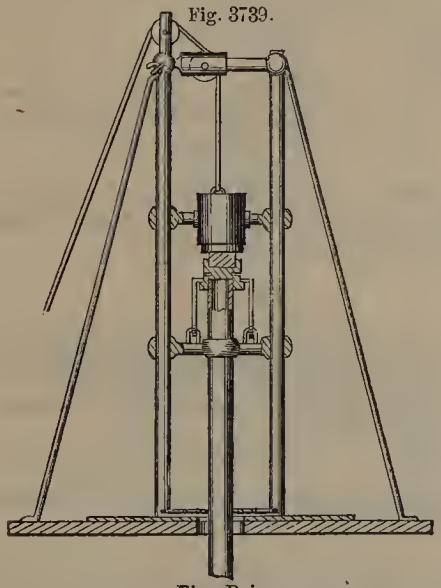


Pipe-Cutter.

Pipe-driv'er. An implement of the general form of a pile-driver, used for forcing into the ground pipes for what are known as "driven wells."

A drive-head is temporarily attached by a stirrup to the upper end of the pipe to receive the blow of the *monkey*. The

Fig. 3739.



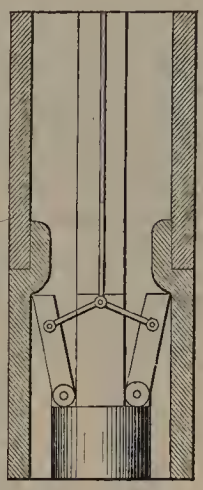
Pipe-Driver.

stirrup is connected with the bar which glides on the guide-rods.

Pipe-grab. A tool to let down into a well-pipe to enable it to be hoisted to the surface. See GRAB.

Some are made to clutch the outside, others the inside, as in the example, in which pawls or wedges on the end of a draw-rod are lowered into the well-tube and expanded against its sides for the purpose of withdrawing it.

Fig. 3740.



Pipe-Grab.

Pipe-joint. A means of connecting adjacent ends of pipes. See PIPE-COUPLING.

Pipe-loop. (*Harness.*) A long narrow loop for holding the end of a buckled strap.

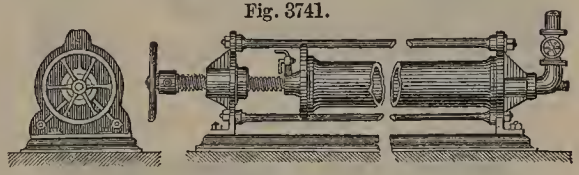
Pipe-mold'ing. A machine for making clay or concrete pipes. See TILE-MACHINE.

Pipe-or'gan One having musical *pipes*, in contradistinction to one having vibrating tongues, and known as a *reed*-organ.

Pipe-prov'er. An apparatus for the purpose of proving steam and water pipes by means of hydraulic pressure. It comprises a metallic bed-plate, on which are fixed two cast-iron head-stocks connected by strong wrought-iron bolts, cast-iron follower with square thread screw, and hand regulating-wheel, screw water-valve, and air-cock. Also a gun-metal pressure-pump inclosed in an iron cistern, and a pressure-gage.

The method of using the apparatus is as follows: The pipe is placed between the head-stocks in contact with rubber rings, and the joints made by screwing up the follower by means of

Fig. 3741.

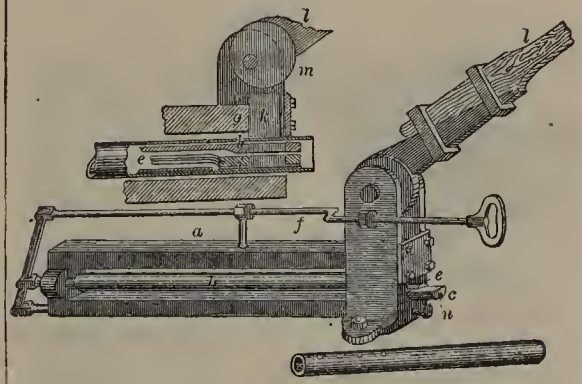


Pipe-Prover.

the hand-wheel The pipe is rapidly filled with water from any convenient source above the machine by opening the water-valve, when the proof-pressure may be applied by the pump.

Pipe-slot'ting Punch. Brigden's machine for punching holes or slots in metallic tubes consists of a frame *a* in which is fixed a strong hollow mandrel *b*. A semicircular wedge *c* is fitted into the mandrel and connected by a rod *e* to a lever at the other end of

Fig. 3742.



Brigden's Pipe-Slotting Punch.

the machine operated by the rod *f*. The frame, mandrel, and wedge are slotted at *g h i*, forming a

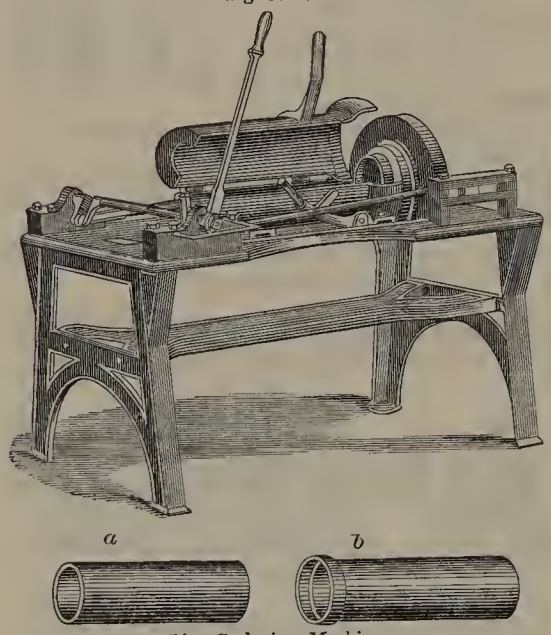
series of openings through which the punch *k* may work.

In using the apparatus the pipe is slipped over the mandrel, and by forcing the rod *f* inward the wedge *c* is caused to enter the pipe and resist its tendency to be bulged inwardly under the action of the punch. The lever *l* is depressed, operating the eccentric *m* and forcing the punch through the upper side of the pipe; the piece of metal cut out is driven through the aperture *h* into *i*. An upward movement of the lever *l* permits a spring to lift the punch, and the rod *f* is pushed inward to withdraw the wedge, after which the pipe may be removed. By a reverse movement of the rod, a small projecting pin on the frame *a* is caused to push the chip cut from the pipe out through the longitudinal slot *n* in the wedge.

Pipe-sock'et-ing Ma-chine'. A machine for finishing the molding process of clay or concrete pipes by making a socket on one end to receive the smaller end of an adjacent pipe when laid.

a shows the pipe before socketing; *b*, afterward. The pipe *a* is placed in the bed of the machine, and the upper clamp

Fig. 3743.

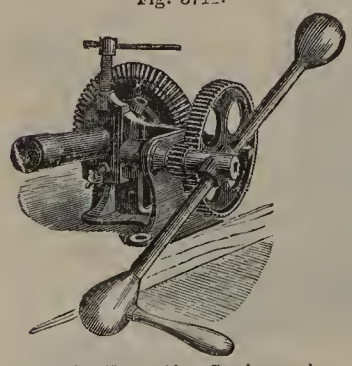


Pipe-Socketing Machine.

brought down and locked. The head-piece, which has the counterpart form of the socket, is then brought forward by the lever, expanding the clay into the shape of the *former*.

Pipe-thread'ing Ma-chine'. 1. A machine of the nature of a screw-stock to cut a thread on the end of a wrought-iron pipe. The figure shows the "Chase" machine fitted for hand-power, motion being transmitted to the several parts by means of gearing; the pipe is shown projecting toward the left, and is held stationary by the adjustable jaws of the pipe-vise. The pipe passes through the center of the gear-wheel, the rotary motion of which is imparted to the die in the die-box by means of studs or guides upon which the die-box freely slides forward as the die passes upon the pipe.

Fig. 3744.

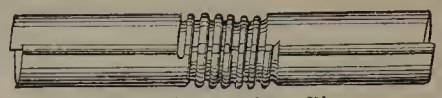


The Chase Pipe-Cutting and Threading Machine.

When *cutting* pipe, the tool-post with the cutter has automatic feed, cutting the ends of the pipe squarely and smoothly.

2. (*Sheet-metal.*) A machine for impressing a spiral groove upon a sheet-metal tube, such as a stove-pipe, so that the end of adjacent sections may

Fig 3745.

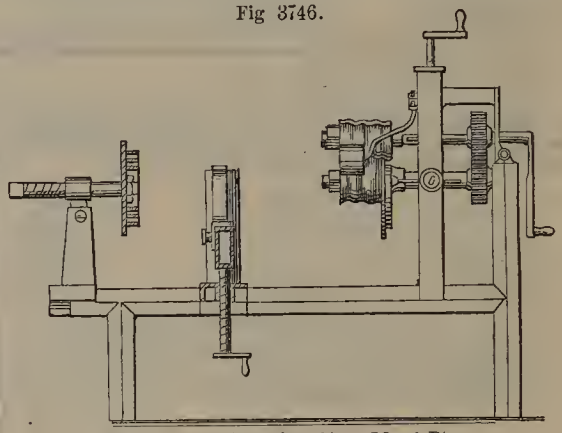


Screw-Threaded Stove-Pipe.

be screwed together, as in the example. The same is done with some kinds of sheet-metal covers for fruit-jars.

Fig 3746 is a machine in which sheet-metal pipe is passed between the two rotating circumferentially ribbed cylinders,

Fig 3746.

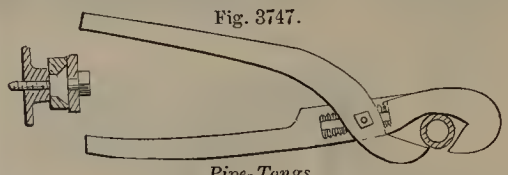


Machine for Threading Sheet-Metal Pipe.

the ribs of the cylinders meshing together. As the cylinders rotate they impress the thread upon the pipe.

Pipe-tongs. A pair of tongs with one short jaw adapted to grasp a pipe or rod. Their range of grasp

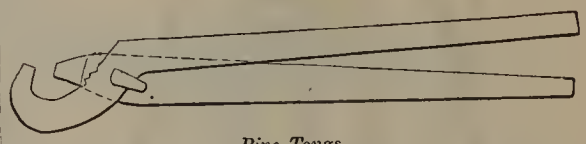
Fig. 3747.



Pipe-Tongs.

is but limited, and a number are provided for varying sizes of pipes. Their grasp is more tenacious than that of a monkey-wrench.

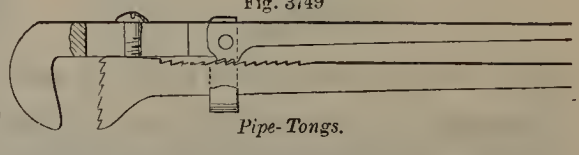
Fig. 3748.



Pipe-Tongs.

Figs 3747, 3748, 3749, show three of the numerous forms of pipe-tongs. See also PIPE-WRENCH.

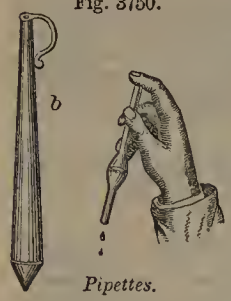
Fig. 3749



Pipe-Tongs.

Pi-pette'. A small glass open-ended tube, used

Fig. 3750.



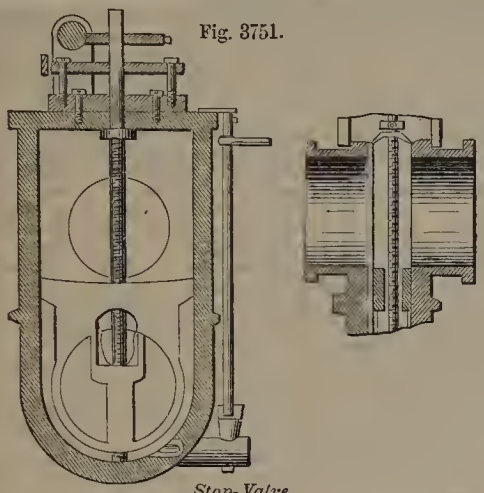
Pipettes.

for transferring small quantities of liquids. Called also a *drop-tube*, from its being used for this purpose. As the pressure of the finger on the upper end is relaxed, the liquid drops from the contracted orifice at the lower end. The *velinche* or *tâte-vin*, which is intended for a *sampling-tube*, may also be used as a *drop-tube*. It is sometimes called a *wine-taster* or *thief-tube*.

Pipe-valve. A stop-valve in a pipe.

In the example, the valve is vertically operated by a worm-wheel and screw-shaft, and when opened slides into a box be-

Fig. 3751.



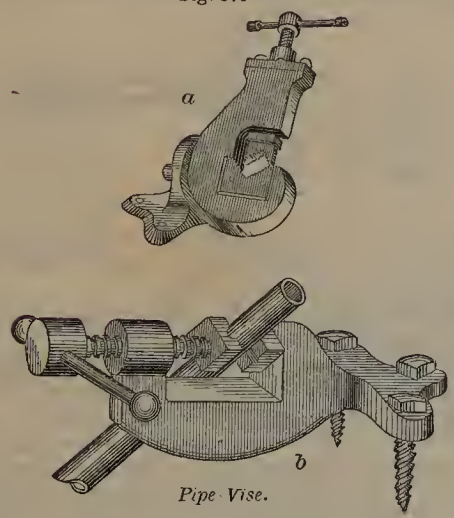
Stop-Valve.

neath the main; the water in the box is discharged by a faucet. There are many kinds. See list under VALVE.

Pipe-vein. (*Mining.*) A vein which contracts and expands, instead of preserving uniform size. The expansions are *bunches*.

Pipe-vise. An implement for holding a pipe

Fig. 3752.

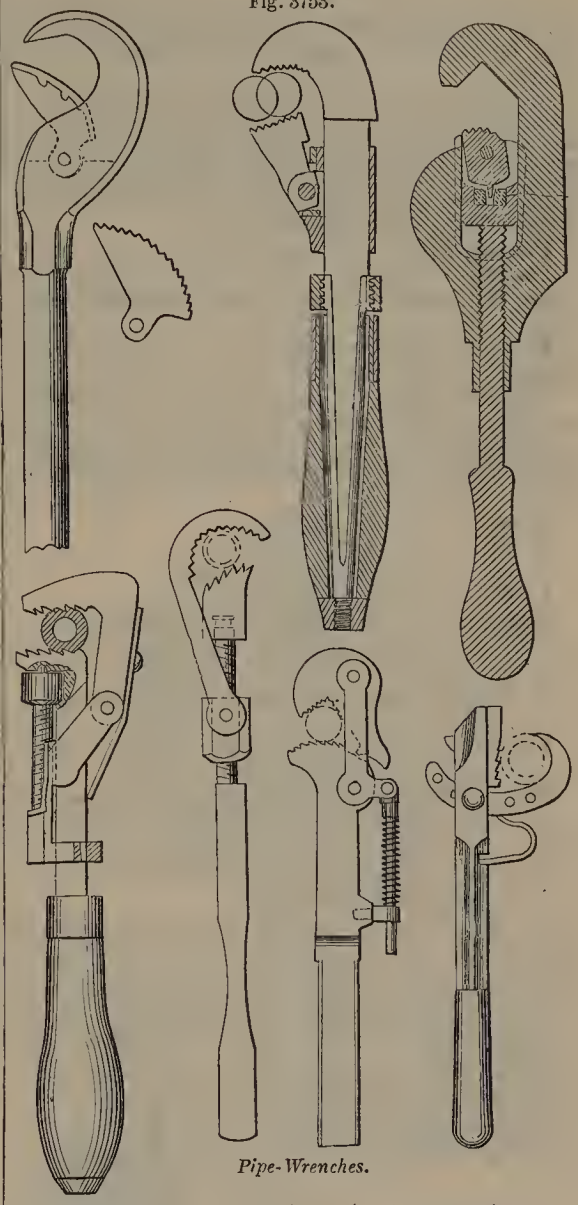


Pipe-Vise.

while being threaded or otherwise fitted. *a* and *b* are different patterns, both for bench use.

Pipe-wrench. An implement with a movable and a relatively fixed jaw, so arranged as to bite together when they are made to grip the pipe, and are revolved in a certain direction around it. The figure shows several kinds, which will be understood without specific description.

Fig. 3753.

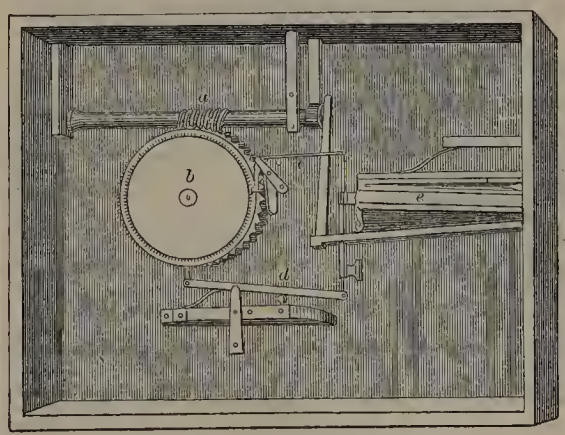


Pipe-Wrenches.

Pip'ing. 1. (*Harness.*) A leather covering to a trace-chain.

2. In a musical toy, — the "piping bulfinch," — on touching a spring the bird is caused to jump out of a box, move its wings and beak, and seemingly

Fig. 3754.



Mechanism of the "Piping Bulfinch."

pipe a tune. The sound, however, is not emitted by the bird, but comes from a concealed pipe operated by mechanism similar to that shown in the figure.

An endless screw *a*, turned by hand or clock-work, rotates a toothed wheel carried by the cylinder *b*, which is set with studs arranged like those on the cylinder of the musical box or barrel-organ, so as to play one or more tunes, by means of two jointed levers *c d* operating a piston in the pipe to produce the required notes; air is supplied to the pipe by a bellows *e* worked by an eccentric on the endless-screw shaft.

Pip'ing-i'ron. A fluting-iron.

Pi-qué'. (*Fabric.*) A cotton goods, figured or plain, and with a crimped surface resembling cordings.

Pi-quée'. (*Fabric.*) Marcella. A heavy cotton goods for vesting, etc.

Pi-qué'-work. A minute kind of buhl-work; inlaying metals in metals, usually.

Pi-ram'e-ter. An instrument for measuring the power required to draw a carriage upon a road or track. A *dynamometer*.

Pirn. 1. A quill or reed.
2. Yarn wound on a shuttle.
3. The bobbin of a spinning-wheel.
4. The wheel of a fishing-rod.

Pi-rogue'. (*Nautical.*) *a.* A large double canoe formed of a hollowed trunk of a tree, or of two canoes united.

b. A narrow ferry-boat having two masts and a lee-board.

Pis-ci'na. (*Architecture.*) A niche in the south side of the altar for a water-basin.

Pi-sé-work. A mode of forming walls of rammed clay. The conformation of the walls is given by means of boards on each side, and after one layer is formed and partially hardened, the boards are lifted to form bounds for another layer.

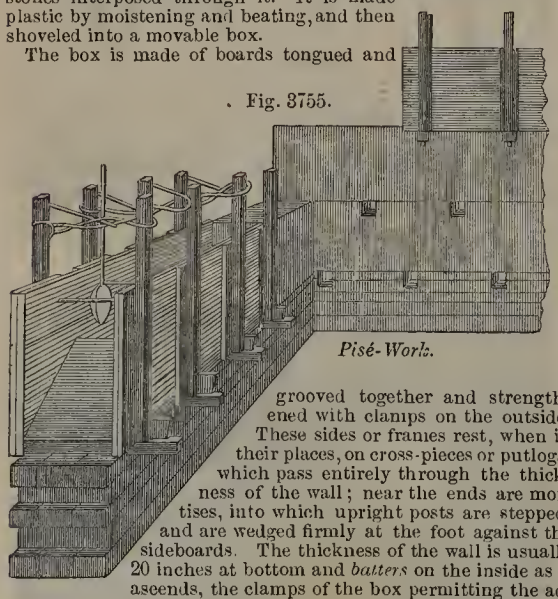
It is allied to the adobe method; but the clay, instead of being formed in blocks, is rammed into place, where it becomes dried by means of the sun and air. In some parts of England and France the practice is universal in houses of moderate and humble pretensions.

The *formacei*, or earth-walls, described by Pliny as existing in Gaul and Spain, are of this character. See WALL, CONCRETE; BÉTON, etc.

The best material for pisé-work is clay with small gravel-stones interposed through it. It is made plastic by moistening and beating, and then shoveled into a movable box.

The box is made of boards tongued and

Fig. 3755.



Pisé-Work.

grooved together and strengthened with clamps on the outside. These sides or frames rest, when in their places, on cross-pieces or putlogs, which pass entirely through the thickness of the wall; near the ends are mortises, into which upright posts are stepped, and are wedged firmly at the foot against the sideboards. The thickness of the wall is usually 20 inches at bottom and *batters* on the inside as it ascends, the clamps of the box permitting the adjustment as required. The sides or frames are made 10 feet long and 3 feet deep; the uprights, 5 feet long, including the tenons, so that they project above sufficiently to enable them to be secured by ropes. The wedges are 9 inches in length, 1½ at the base, and 5 inches at top. The bottom of the boards incloses about 2 inches of the top of the wall already made. The sides are held apart by transverse stays, which may be shifted from time to time for the convenience of the workman, who is wetting, working, and ramming the material as it is thrown in. Three or four inches of material is spread at a time, and is then well tramped and rammed. The frame is shifted from time to time, until all the wall is built on a given level to a certain hight; after an interval for drying, another thickness is laid on. Door and window ways, sleepers, and joists are built in as the work proceeds.

Pis'tol. A form of fire-arm adapted for use with one hand. The modern form of pistol is a breech-loader, using metallic cartridges.

It is said to have been invented at Pistoia, in Tuscany, by Camillo Vitelli, in the sixteenth century. The German cavalry seems first to have used them, and their use caused the lance to be abandoned. At the battle of Ivry, 1590, it appears that the French gentlemen of the king's army lost ground by the change, finding it difficult to meet the charge of the enemy's lancers without taking open order and — scattering.

The general appearance of the pistol is so well known that the weapon hardly needs description here.

About 1857, those for the United States cavalry were furnished with a detachable butt-piece fastened to the butt of the pistol by a screw, so that the arm could be fired from the shoulder; the weapon, with this addition, was termed the pistol-carbine. It was soon entirely superseded by Colt's and other revolving pistols. See REVOLVER.

The dueling-pistol of the last century was a finished weapon, having a long, slim barrel, and fired by a hair trigger. The stock and barrel were generally inlaid with silver. Much pride and pleasure were found in their possession and curious modifications, — *saw*-handles and *cross*-handles, and so on. Rifling for pistols was not generally adopted until some time after it had been used in long-barreled guns.

The Derringer pistol, which has some celebrity, is short-barreled, of very large caliber, and has been compared to a pocket-howitzer. It is a very effective weapon at short range. The latest pattern of Derringer is a single-barreled breech-loader, weighs about 8 ounces, and carries a half-ounce ball.

Toy pistols have been made which project a buckshot with considerable force by the explosion of a percussion-cap. Toy pistols for firing an arrow by the force of a spring, or projecting a cork by the expansion of air which has been previously compressed in a chamber, are also common.

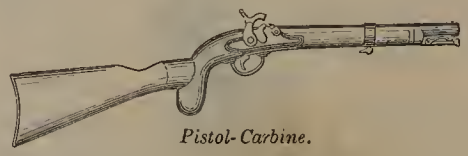
The earliest form of pistol was used by the English cavalry in 1544. The earliest form of revolving, cylindrical breech, whose chambers are brought consecutively in line with the barrel, is found in the English United Service Museum, and is supposed to date from the time of Charles I.

The Colt pistol, which has attained the highest celebrity, was introduced from the United States into England in 1853. See REVOLVER.

The English cavalry-service pistol has a length of 13¾ inches; barrel, 8 inches; weight, 40 ounces; caliber, .577 inches; rifling, 5 grooves, having one turn in four feet.

Pis'tol-car'bine. (*Fire-arms.*) A horseman's pistol provided with a removable butt-piece, which

Fig. 3756.



Pistol-Carbine.

may be secured to its stock by a spring-catch, or detached, so that the weapon may be fired either from the hand or the shoulder.

Pis'tol-pipe. (*Metal.*) The tuyere of a hot-blast furnace.

Pis'tol-rout'er. A kind of carpenter's plane. A router with a handle like a pistol-stock.

Pis'ton. A device so fitted as to occupy the sectional area of a tube and be capable of reciprocation by pressure on either of its sides. It may be of any shape corresponding accurately to the bore of the tube; but the cylindrical form is almost exclusively employed for both, as in the common pump and the steam-engine. One of its sides is fitted to a rod, to which it either imparts reciprocatory motion, as in the steam-engine, or by which it is itself reciprocated, as in the pump. In the former case, it has no opening leading from one side to the other, and is termed *solid*, though generally not really so; but in the latter, an aperture controlled by a valve permits the

passage of the fluid from one side to the other during its downward movement. A distinction is, however, made in pumps; the *solid* piston being known as a *plunger*, the *hollow* piston as a *bucket*. The piston usually requires *packing* to cause it to fit closely within its cylinder, and at the same time allow its free backward and forward motion. For this purpose, its ends are usually formed by two connected disks, or have a deep annular groove between them for receiving the packing material, which may be hempen cord wound around it, or other somewhat expansible substance, which will not wear too rapidly nor cause excessive friction. In modern practice, metallic rings, cut through at one side, so that their expansion may compensate for any wear, are largely employed in the steam-engine. The simple form of piston required for the pump will be more fully explained under the head PUMP, this article being more particularly descriptive of the various kinds used in the steam-engine.

The earliest known use of a piston in a cylinder is found in some of the ancient blowing-machines of the native metallurgists of Asia and Africa. This was much earlier than the air-pumps of Ctesibus, 150 B. C. See "Spiritalia Heronis."

It is believed that Papin's pistons were of wood, and that Cartwright was the first to use a metallic piston.

One of Cartwright's valves was in the piston, and was tripped by the contact of the valve-stem with the end of the cylinder.

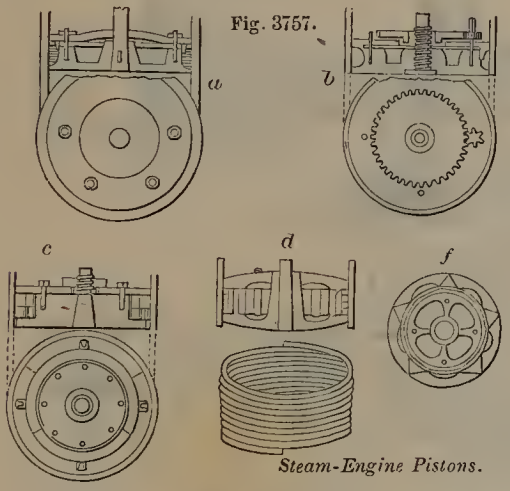
James Watt found the piston imperfectly fitted in a roughly bored cylinder. The principal packing was a body of water on the upper surface.

He patented the lubricant, 1769, preferring mutton tallow, but hemp and tallow had long been used. To this he sometimes added plumbago-dust. A common piston till a comparatively late date was a double cone of wood banded with leather strips.

This was superseded by a metallic piston, turned to fit neatly in the cylinder, and having a circular plate on each side clamping two leathers, cupped and chamfered off to an angle of 45°.

The piston for the atmospheric engine was a plate of cast-

Fig. 3757.



Steam-Engine Pistons.

iron, about ⅛ inch less in diameter than the cylinder, and 1½ inch in thickness, with a rim about 4 inches from the edge. Beyond this a flat ring is fitted and the parts are screwed together, after hemp and tallow have been inserted between them to form the packing.

The hemp-packed piston (*a*, Fig. 3757) is in common use. The bottom is accurately fitted to the cylinder, and a portion of the periphery is cut away to admit of a gasket of unspun hemp or soft rope to be wound evenly around it, to form the packing. This is compressed by means of a plate and screws, so as to expand it against the inside surface of the cylinder, making a steam-tight joint.

The piston-rod is attached by an enlarged head, screw-nut, and key to the bottom of the cylinder, which has a central boss to strengthen it at that point. The piston is lubricated by melted tallow or oil introduced into the cylinder by a funnel and a pipe with a double stop-cock.

Wolf's piston (*b*) was so arranged as to be tightened without removing the cylinder cover. A screw-thread is cut on the cylinder-rod, which is also surrounded by a toothed wheel engaging a pinion on a vertical rod passing through the cylinder cover. By turning this, the screw-thread is caused to draw the two piston-heads together, tightening the packing.

Cartwright's piston (*c*) resembled the wedge metallic piston in construction. The pieces of which it is formed having a determined curvature, and being too stiff to yield readily, it did not well adapt itself to inequalities in the cylinder, if the latter had not been accurately bored.

Brass rings as a substitute for the hempen packing in pistons was invented by Murdock and Aiken of Glasgow, in 1813.

The wedge metallic piston (*e*) is formed by rings cut into a number of parts, pressed upon the cylinder by wedges, which are kept in their places by springs.

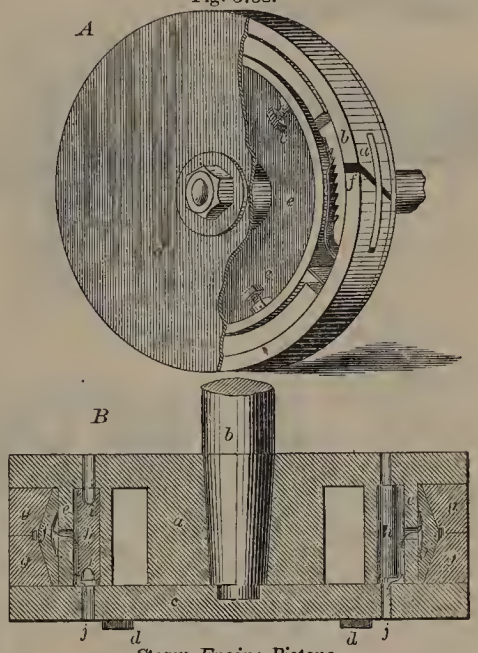
Jessop's piston (*d*) has an expanding coil of metal of spiral form surrounding the piston-body between the two piston-heads, filled in with hemp packing, which assists the outward pressure of the coil and helps to prevent the passage of steam.

The spring metallic piston (*f*) has wedges inserted behind the metallic rings, forming its perimeter, which bear against springs that force the rings outward into contact with the surface of the cylinder.

In *g* the wedges are dispensed with, the springs bearing directly against the metallic rings.

In Askwith's packing arrangement (*A*, Fig. 3758), a divided ring is inclosed between the piston-heads *d e*; a recess is formed

Fig. 3758.



Steam-Engine Pistons.

at the point where its two ends nearly meet, into which a pivoted partition-piece *a* shuts, so as to prevent the passage of steam through the cut *f*; on the interior is a toothed rack *b*, in which a spring engages, to maintain the expansion of the ring, which is regulated by set screws *c c*, working through the flange *g* on the piston-head; a small quantity of steam is admitted between this flange and the ring, so that the piston is both steam and metal packed.

In Jacob's (*B*), the packing is effected by steam entering through the apertures *i j*, alternately above and below the plug *h*, which acts as a valve, and passes to the back of the ring *f*, the wedge-shaped face of which, under the influence of the steam-pressure, serves to force outward and apart the outer segmental rings *g g*, causing them to act equally against the interior surface of the cylinder, forming an effectual packing.

The following may be cited as the distinguishing features of pistons. They principally concern the lapping of rings, which are forced out by various means.

Screws alone.
Springs alone, supported.
Springs alone, unsupported.
Springs and wedges.
Springs and screws.
Wedges and screws.
Wedge, rack, and spring.
Cone and axial screw.
Springs on outside with wedges.
Steam admitted through apertures beneath rings.
Steam admitted through face of packing.
Steam admitted through valves.
Flexible outside disks.
Pistons with grooves for wire or jute.

Fig. 3759 shows a number of steam-pistons with peculiar modes of packing.

a a' is Askwith's, 1867, in which the divided portion is covered by a break-joint plate held to its seat by a spring. The outer ring is set out by screws projecting from the inner ring. *a'* shows a dowel-plate.

b is Brown's, 1869, which has metallic springs, thrusting outwardly the elastic break-joint rings, and seated upon a supporting boss.

c is Fairbanks's, 1872, having a corrugated expanding spring, screwed fast to the packing-ring at its midlength.

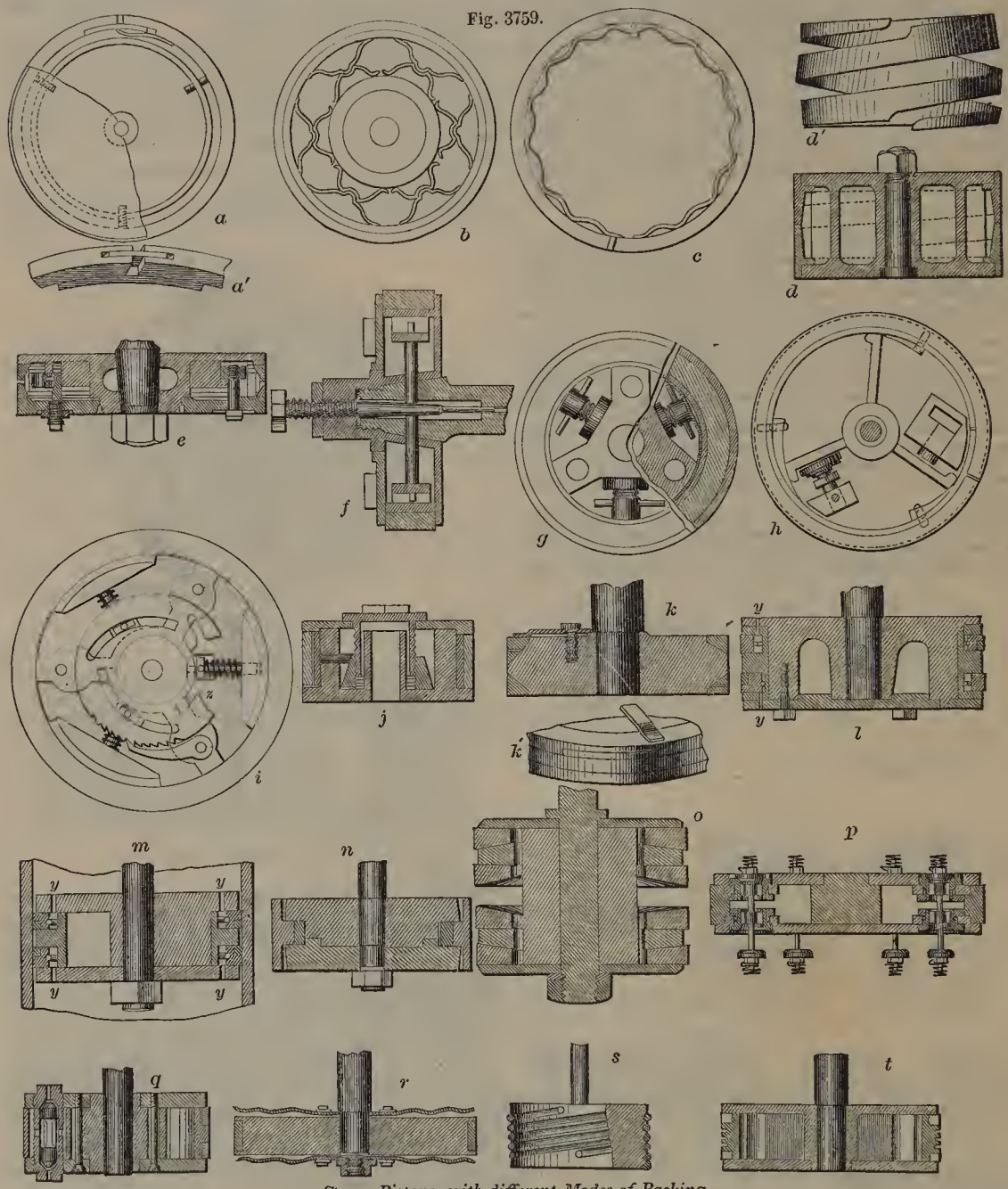
d d' is Lowe's, 1866, which has a beveled spiral spring, inclosed between a head and follower, and expanding the rings. *d'* shows the detached ring expanded laterally and vertically.

e, Bower and Qualter's piston, 1866, has springs driven against the rings by the force of wedges at the back. The wedges are set up by screws.

f, Hoagland's, 1857. By turning the axial screw the conical shaft is driven against the radial bars, which drive against the springs and expand the circumferential ring.

g is Blake's piston, 1871, a part of which is shown with the cover removed. It has screws which force a body of soft vulcanite or metallic springs against the outer rings of the piston. The screws are turned by bars.

Fig. 3759.



Steam-Pistons, with different Modes of Packing.

h is the Huss piston, 1871, combining wedges and screws. By turning the screws, the radial bars projecting from the central boss are forced against the wedges on the inside of the expanding ring.

i is Allen's piston, 1873. It has wedges and springs, and a rack to hold it to its set The portion of the wedge-plate at *z* is broken away to expose the rod and the spring which bears against the segment which distends the packing-ring. The rotation of the wedge-plate acts upon each of the three.

j is Carey's piston, 1873, which has an axial screw and a conical nut, the latter pushing against the stems of the followers to force outwardly the peripheral piston-ring.

k k' are Adams's piston, 1868, in which the piston-rings are wedge-shaped at their overlapping portions, and are driven outwardly by the lateral pressure of a wedge actuated by springs on the face of the piston.

l is Buchanan's piston, 1865, in which the piston-rings are expanded by steam admitted behind them, through apertures on each face leading to the groove in which the rings work. These openings are at three points of the circle, and show at *y y* in the figure.

m is the Dunbar piston, 1860; and is somewhat similar to the last stated.

n, the Hunt piston, 1867, has a T-shaped packing-ring, whose

stem is packed in its groove, and which is expanded by steam below its extended flanges.

o is the Smith pistou, 1867. Steam is admitted through a central groove in the packing, and passes behind the rings.

p, Witty's valve, 1869, in which steam is admitted through valve-ways to the space behind the ring. The contact of the valve-stem with the end of the cylinder actuates the valve.

q is Hedden's valve, 1863, in which steam is admitted by valves in the piston into the space behind the expansible ring.

r is Cabell's pistou, 1866. It has flexible outside disks, whose peripheries move in contact with the surface of the cylinder.

s is Cameron's, 1866. It has a coil of wire in a spiral groove around the piston.

t is Clark's, 1865. It has a grooved periphery for wire or jute.

Gale's patent, July 21, 1857, has a pistou with circumferential grooves occupied by steam and water of condensation, which act as a packing. The same feature is fouud also in the stuffing-box, which is grooved iuteriorly.

The dimensions and evaporative capacity of the steam-generator for a given duty are determined by the number of cubic feet of water required to propel a piston of a given area a given number of feet per hour.

Say, for instance, that to overcome the resistance of the machinery to be moved a steam pressure of 20 pounds per square inch on a piston having an area of 5 square feet will be required. Assuming the required speed of the piston to be 200 feet per minute to give the necessary velocity to the machinery, the calculation stands thus: The speed of 200 feet per minute is 12,000 feet per hour; the quantity of steam at 20 pounds' pressure to the square inch is, therefore, 12,000 × 5 (the area of the piston) = 60,000 cubic feet of steam per hour. Steam at 20 pounds' pressure to the square inch bears the proportion to water of 1,281 to 1. Therefore, 60,000 ÷ 1,281 = 47, nearly, which represents 47 cubic feet of water evaporated per hour; say, equal to 47-horse power.

Pis'ton-bel'lows. In Fig. 3760, *a* represents a portable, single-acting Chinese bellows. Air is admitted to the tube through an inwardly opening valve, when the piston is drawn backward and is

Fig. 3760.

Piston-Bellows.

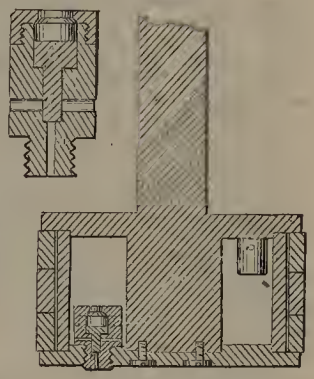
forced out by its forward movement through a valve at the side opening outwardly.

b is a piston-bellows, formed by boring out the trunks of trees, used by the natives of Madagascar for smelting and forging iron. The air-induction valve would appear to be in the piston. The operator sits on and between two of the tubes, working a piston with each hand. The furnace, seen between the two pairs of bellows, is merely a hole roughly lined with stone and plastered with clay.

Pis'ton Blow'ing-ma-chine'. That form of blowing-machine in which the air is driven from a cylinder by a reciprocating piston. See page 305.

Pis'ton-head. That portion which fits into and reciprocates in the cylinder. The *head* is distinct from the rod. A somewhat unnecessary distinction. See PISTON.

Fig. 3761.

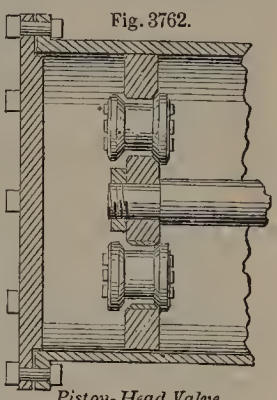


Piston-Head.

In the example, the hollow head has a self-acting valve, by which steam is admitted to the pistou for the expansion of the packiug-ring. The areas of the ends of the valve vary in proportion to the desired difference of pressure betweeu the steam on the outside and that on the inside of the piston.

Pis'ton-head Valve. A valve in a piston to admit steam, either to the interior, to expand the packing-ring, as in Fig. 3761, or, as in the example (Fig. 3762), in which it acts to change the steam. As the piston reaches the end of its stroke, the valves in the piston-head are opened by contact with the cylinder-head, and admit steam from behind the piston to that space about to receive the incoming steam.

Fig. 3762.



Piston-Head Valve.

Pis'ton-pack'ing. A material for preventing the leakage of steam between the piston-head and the cylinder in which it works. For mechanical devices, see PISTON.

Among the materials and modes of piston packing may be enumerated the following:—

The first list is from English patents, and gives the number and year of the patent.

5,032 of 1824. The piston is padded with linen or woolen material, placed smoothly on both sides of the piston, with a thin piece of paper between. A circle of metal is placed on each side of the padding and screwed together.

7,437 of 1837. Rings of cloth diminishing in diameter toward the center and coated on both sides with a solution of india-rubber.

7,800 of 1838. Grooves around the piston filled with an alloy of zinc, tin, and regulus of antimony.

9,411 of 1842. Cork between two plates screwed together. Around the edge of the piston and the cork is a thin band of brass, which forms the rubbing surface of the piston.

13,682 of 1851. Thin metallic rings laid one upon another, and backed by canvas impregnated with a composition of fat, graphite, sulphur, and alum.

41 of 1852. Cuttings of india-rubber burned and mixed with charcoal, graphite, lead, and lampblack.

384 of 1852. Tuck's patent. Rolls or folds of canvas coated with india-rubber, and inclosing strands of india-rubber.

1,025 of 1854. Spun yarn saturated with solution of india-rubber.

1,865 of 1854. Core of india-rubber within a roll of canvas, coated with solution of india-rubber.

2,617 of 1860. Leather band covered by vulcanized rubber and another band. Sometimes a covering of wire-gauze.

2,415 of 1863. Wire and woolen threads, interwoven, placed over canvas treated with grease, graphite, sulphur, and alum.

3,148 of 1863. Esparto grass steeped in caustic soda; then boiled in solution of carbonate of soda; dried, oiled, and opened for spinning.

19 of 1865. Web formed in braiding-machine, having elastic india-rubber core; passed between smoothing-rollers and then through lubricant.

555 of 1868. Interior of hemp, jute, etc., covered with cotton duck.

1,120 of 1868. Paper, cut to size, is treated with powdered soapstone and graphite, then spread on cloth or rubber, rolled

up into a cylindrical form and dried; then saturated with hot tallow, cooled, drained, and cut into rings.

602 of 1871. Cotton, woolen, or flax flocks or waste, subjected to pressure in molds.

897 of 1871. Asbestus strengthened by cord.

2,515 of 1871. Strips of canvas, etc., wound upon a rod, from end to end, so that each thickness overlaps the preceding one, cemented together. Rope thus formed filled with tallow.

549 of 1872. Elastic band of wire and asbestus interwoven.

613 of 1872. Strips of cork inclosed in fabric. Brass gauze as interior lining.

995 of 1872. Fabric treated with paraffine, india-rubber, lead, zinc, graphite, sawdust, and quicksilver.

3,126 of 1872. Rubber tube with soft rope within.

The following are United States patents. The figures give the numbers and years of the patents: —

34,283 of 1862. Layers of flax, asbestus, and wool, placed alternately in a tube full of water, through the bottom of which steam passes. After being pulped in this they are compressed in molds.

36,987 of 1862. A core of cork with a loose braiding-cover; over this twine with cotton sliver wound about it. The whole steeped in hot water and tallow.

44,475 of 1864. Pulverized soapstone and asbestus mixed with cotton.

45,261 of 1864. Packing-yarn saturated with a mixture of pulverized charcoal, molasses, and tallow; then covered with canvas sewed on.

47,119 of 1865. A tube of fabric, sewed or braided, filled with sawdust, soapstone, graphite, whiting, zinc paint, white lead, resin, flaxseed meal, etc. Yarn may be saturated with this before braiding. Metallic thread braided cover.

63,285 of 1867. Strands of cotton saturated with powdered soapstone, or other lubricant, and covered with yarn.

64,688 of 1867. Harl or roving of hemp covered with braided material or fabric.

64,995 of 1867. Strands of jute or yarn passed through powdered soapstone; twisted into a rope; passed through melted paraffine; covered in a braiding-machine; then through paraffine.

73,454 of 1868. Wire or vegetable fiber, braided one over the other, with lubricants between.

77,275 of 1868. Lubricant of stearine, powdered soapstone, etc., is introduced into packing while being twisted or braided.

77,902 of 1868. Yarn run from reels through a vat of oil, wax, and powdered soapstone, and twisted into rope.

101,425 of 1870. Core of asbestus, with canvas cover coated with rubber, vulcanized or otherwise. Pulverized asbestus spread on the canvas cover, or the latter may be of pulpy asbestus and a fibrous or glutinous material.

102,958 of 1870. Pulp of rags and paraffine.

108,284 of 1870. Sliver or hempen rope impregnated with a vehicle of melted paraffine, with graphite, burnt hair, etc.

108,285 of 1870. A layer of fiber on a plate saturated with a mixture of melted paraffine or tallow and soapstone or graphite, compressed into sheets.

108,286 of 1870. Felt impregnated with a mixture of graphite, soapstone, and burnt hair, while in a vessel of paraffine.

108,722 of 1870. Material coated with rubber is punctured, and graphite or other lubricant forced therein.

108,931 of 1870. Graphite mixed with comminuted leather and paraffine.

109,239 of 1870. Loose yarn run into slivers, twisted and combined with melted paraffine, graphite, soapstone, etc.

110,582 of 1870. Rubber, graphite, and soapstone combined.

110,583 of 1870. Sponge impregnated with graphite and glycerine.

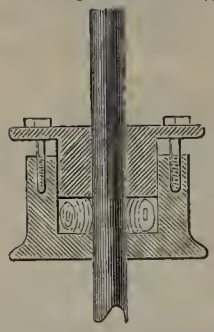
110,584 of 1870. Hair or wool felted with graphite, asbestus, etc., consolidated by action of water.

131,645 of 1872. Long fibers of wool and asbestus covered with metallic or fibrous material with lubricants between.

Somewhat similar materials are used for the pistons of pumps, though the common device is a leathern disk a trifle larger than the diameter of the bowl.

Pis'ton-rod. The round rod which connects the piston with the cross-head or crank of the steam-engine, as the case may be; or the pump-handle with the plunger or bucket.

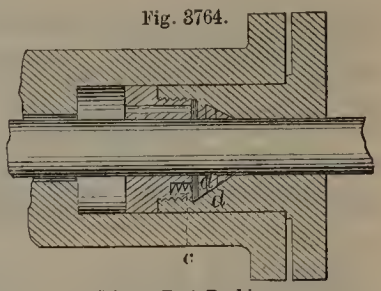
Fig. 3763.



Piston-Rod and Stuffing-Box.

The piston-rod passes through a steam-tight collar, known as a *stuffing-box*, as in the example, in which cork is compressed by the gland.

Fig. 3764.



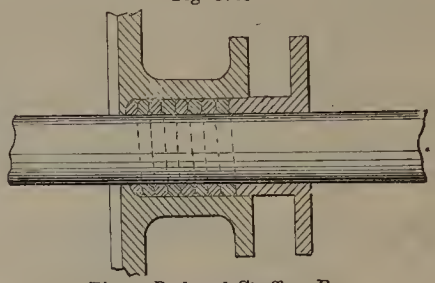
Piston-Rod Packing.

Pis'ton-rod Pack'ing. A material or device around the piston-rod to prevent leakage of steam from the cylinder.

In the example, the packing is pinched between the conical gland *d* and the perforated collar *c*, through which steam is admitted to the packing.

In Fig. 3765, the strands of hemp are wound on wire, and

Fig. 3765.



Piston-Rod and Stuffing-Box.

form annular sections or a coil around the piston-rod in the stuffing-box.

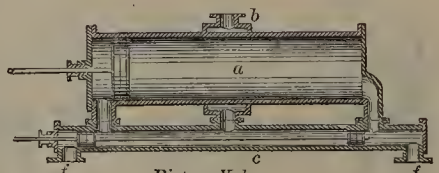
Pis'ton-spring. A coil in the circumferential groove of a piston to expand against the cylinder and form a packing.

A spring inside a piston-head to expand the rim against the cylinder. See PISTON.

Pis'ton-valve. A valve consisting of a circular disk, which reciprocates in a cylindrical chamber. It is sometimes preferred to the slide-valve, as it is readily packed and its friction is less.

a is the cylinder; *b*, the steam-pipe, having a belt around the

Fig. 3766.

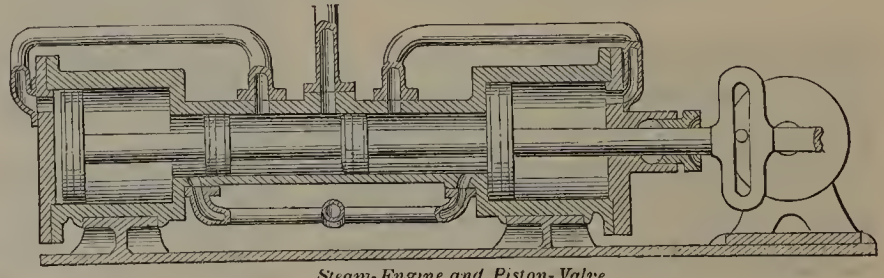


Piston-Valve.

cylinder by which the steam reaches the valve-chamber *c*. The valves are on a single rod, and *f f* are the eduction passages.

In Fig. 3767, the two piston-valves are on the stem of the piston, and govern the induction and eduction ports, through

Fig. 3767.



Steam-Engine and Piston-Valve.

which steam is admitted to be conducted from the respective cylinders.

Pit. 1. The shaft of a mine.

a. Pumping-pit; a shaft in which the pumps and hydraulic machinery work.

b. Working-pit; a shaft in which the mineral is hoisted and the supplies and workmen lowered.

c. Engine-pit; the shaft in which the engine works.

2. (*Founding.*) A cavity or hollow scooped in the floor to receive cast-metal.

3. A vat in tanning, bleaching, dyeing, or in washing alum earth, etc.

4. A sunken place in which charcoal is piled for burning.

Pitch. 1. (*Machinery.*) *a.* The distance between the threads of a screw measured on a line parallel to the axis. The *depth* is the radial measurement.

b. The distance between the centers of two adjacent teeth in a cog-wheel, measured on the *pitch-line*, which is concentric with the axis of revolution and at such a distance from the base of the teeth as to have an equal rate of motion with a similar line in the cog-wheel with which it engages.

c. The *pitch* of a rivet is the distance apart from center to center. It is four diameters in seams and butts of plates, and eight diameters in angle irons and bars. See RIVET.

d. The distance between the stays of marine and other steam boilers. In marine boilers it is usually from 12 to 18 inches.

2. (*Carpentry.*) The inclination of a roof. This is expressed, —

a. In angles, as 30°, 45°, etc.

b. In parts of the span, as one half, one quarter; indicating that the elevation of the comb is one half or one quarter of the span. When the hight is half the breadth the angle of the slopes is a right angle.

c. In the proportion which the rafters bear to the span.

The *common* pitch, so called, has a rafter three quarters the length of the span.

The *Gothic* has a *full* or *whole* pitch, the rafters being the length of the span, making an equilateral triangle.

The *Greek* has a pitch $\frac{1}{9}$ to $\frac{1}{7}$ of the span, giving an angle of 12° to 16°.

The *Roman* has a pitch from $\frac{1}{5}$ to $\frac{2}{9}$ of the span, giving an angle of 23° to 24°.

The *Elizabethan* has rafters longer than the span.

3. (*Architecture.*) The *rise* or versed sine of an arch.

4. (*Mining.*) A lode or portion of a lode let out to men to work by the piece or by a percentage of the product.

5. (*Saws.*) The pitch of a saw is the *rake* or inclination of the face of a tooth. The *space* is the distance between the points of the teeth. The *rake* is a forward slant of the *face*, not common, but found in some saws.

6. (*Planes.*) The slant of a plane-bit in its stock. The pitch is regulated by the angle of the *bed*. The spokeshave has an angle of from 25° to 30°. The *common pitch* of a bench-plane is 45°, and is used for pine and other soft woods. *York* pitch of 50° for bench-planes working in hard and stringy woods; mahogany, for instance. *Middle pitch*, 55°, for molding-planes and smoothing-planes for mahogany and similar woods. *Half pitch*, 60°, for molding-planes in wood difficult to work. As the pitch becomes steeper, it becomes a scraping action. Pitch of scraping and metal planes is 80° to vertical.

In the miter-plane the chamfer of the bit is set upward; the flat side rests on a bed of 25°, the angle of the bit is 35°, so that the cutting-edge has an elevation of 60°.

7. (*Water-wheel.*) In overshot water-wheels, the *bucket-pitch* is a circular line passing through the *elbows* of the buckets. The elbow is the junction of the *floor* and the *arm*, which form the *bucket*. See BUCKET.

8. (*Paddle-wheel.*) The *pitch* of the paddles is the distance between them, measured on the circle which passes through their centers. It is commonly from 1.6 to double their depth.

9. (*Propeller.*) The pitch of a propeller-screw is the length, measured along the axis, of a complete turn.

A *gaining-pitch* is one in which the pitch gradually increases from the *leading* to the *following* edge.

10. (*Music.*) The acuteness or gravity, hight or depth, of any particular sound in the compass or range of notes comprehended by any voice or instrument. A musical sound is produced by a series of vibrations recurring at precisely equal intervals; the greater the number of vibrations in a given time, the more acute or higher the pitch.

The standard or concert pitch has long been a vexed question, although now pretty well settled. For a long series of years prior to 1839 it had been gradually rising, much to the inconvenience of public singers. The C tuning fork in use in 1699 made 489 vibrations in a second, while in 1859 the number of vibrations had increased to 538. In England, in 1842, Mr. Hullah, as a public instructor, and under the sanction of the Committee of Council on Education, fixed a standard of 512, which has an especial convenience, as being a power of 2. In France, in 1858, the Imperial Government fixed it at 522. It was on all sides agreed that the then existing opera-pitch of 546 was too high and painful to soprano singers. Sir John Herschel — a high authority — strongly recommended 512; but instrumental performers stated that, while they could lower the pitch to 528, even at that some of them would be compelled to get new instruments. The Committee of the Society of Arts therefore fixed the standard at 528.

Pitch-back Wheel. (*Hydraulic Engineering.*) A kind of water-wheel, in which the water is turned at an angle with its direction in the flume before descending into the buckets.

Pitch-block. A cushioned seat of a concave hemispherical form, in which sheet-metal ware is held while being chased. See CHASING-TOOL.

Pitch-chain. Vaucanson's chain. One composed of metallic plates bolted or riveted together, to work in the teeth of wheels.

Pitch-cir'cle. (*Gearing.*) The circle of contact of a cog-wheel which meshes with a corresponding cog-wheel or rack.

Pitched Fas-cine'. A fagot of dry twigs, covered over with incendiary composition, and used to set fire to buildings or to light up works. It is made in the same way as common fascines, except leaving a cylindrical space in the axis, is bound with strong wire, and is first coated with a composition of twenty pitch and one tallow, and, when hardened, a second coat of equal parts of pitch and resin is given the fascine, which is afterward primed at each end with rock-fire.

Pitched Work. (*Masonry.*) Work in rubble or undressed stones which are not thrown in indiscriminately (*pierre perdue*), or laid regularly (*coursed work*), but in which the blocks are *pitched* or tossed into place with a certain degree of regularity, so as to bind one another in place. It is used in the facing or upper courses of breakwaters, the slopes of jetties, and on similar maritime constructions.

Pitch'es. The guide-pins which direct the floor-cloth printer in placing the blocks on the canvas so that the respective dots of color will fall into the right places in the pattern.

They answer as the register-points in chromo-

lithographic printing, in which the paper is placed successively on stones with different-colored inks; the points penetrating the paper preserve the *register*.

A sheet of paper on the *tympan* of a printing-press acts as a guide in placing the paper thereon in printing, so that the matter shall occupy the right place on the page. Where the printing is in more than one color, the *tympan-sheet* acts as a register.

Pitch'fork. A husbandman's fork of two or three tines for pitching hay, straw, or sheaves, or of four tines for manure.

Pitch'ing. (*Hydraulic Engineering.*) A facing of dry stone laid upon a bank, to prevent the wear by waves or currents.

Pitch'ing-piece. (*Carpentry.*) The piece against which rest the upper ends of the *carriage-pieces, notched boards,* or *rough-strings,* supporting the steps of a stairs. An *apron-piece.*

Pitch'ing-tool. 1. (*Watchmaking.*) A tool used in placing wheels between the plates of a watch.

2. (*Mining.*) A kind of pick used in commencing a hole.

Pitch-line. (*Gearing.*) The circle described by the extremity of the primitive radius.

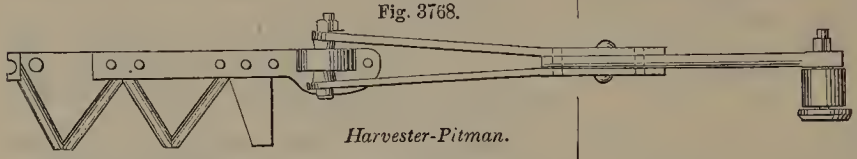
Pitch-pipe. (*Music.*) A flute or free-reed pipe tuned to a given pitch, and used by choristers as a tuning-fork to give the required elevation of the voice. The reed-pipe has a given note. The flute-pipe may have a piston and a range of adjustment.

Pitch-wheels. (*Gearing.*) Toothed wheels in machinery or in a train working together.

Pit-coal. Fossil coal. Stone coal.

Pit-cock. A cock to discharge air from a water-pipe. See also PET-COCK.

Fig. 3768.



Harvester-Pitman.

Pit-kiln. An *oven* for coking coals; in contra-distinction to a *mound.*

Pit'man. (*Machinery.*) The rod which connects a rotary with a reciprocating object, as that which couples a crank with a saw-gate, or a steam-piston with its crank-shaft. So called from the lower man of a pair who worked in a pit at the lower end of the saw.

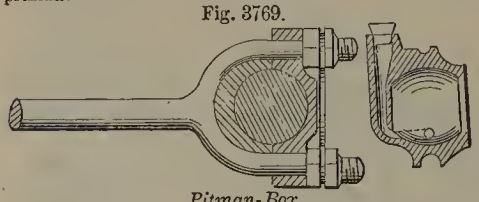
The word has now a local application to the man in charge of the drainage-pumps in a pit or shaft.

The more general use of the word refers to a bar proceeding from a crank or wrist, such as the rod connecting the cutter-bar of a harvester with the wrist on the crank-wheel.

Pit'man-box. The stirrup and brasses which embrace the wrist of the driving-wheel.

In the example, the driving-wrist is formed with a ball and flange, on which is fitted a cap having an oil reservoir to lubricate the joint, and apertures to receive the forked end of the pitman.

Fig. 3769.

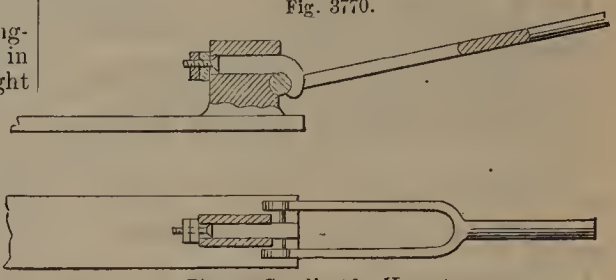


Pitman-Box.

Pit'man-coup'ling. A means of connecting a pitman to the object which it drives.

In the example, the bolt is secured to the forks of the pitman, and is held snugly in its semi-cylindrical socket by an adjustable hook-bolt.

Fig. 3770.

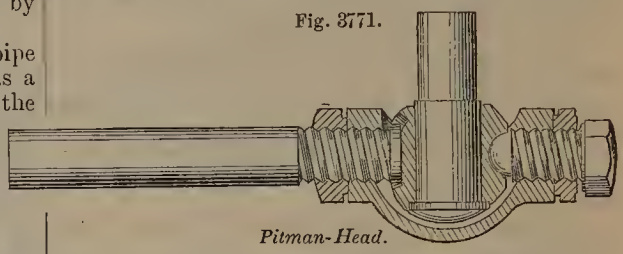


Pitman-Coupling for Harvesters.

Pit'man-head. The block or enlargement at the end of a pitman, at which point its connection is made to the object by which it is driven or which it drives.

The means are usually a strap, gib, and key, but in certain machinery, as in harvesters, another arrangement is preferred, as in Fig. 3770, or in the example, in which the wrist revolves in the divided box, which is supported on a screw at the end of the pitman, and a pivot from the opposite side of the oil-cup; a

Fig. 3771.



Pitman-Head.

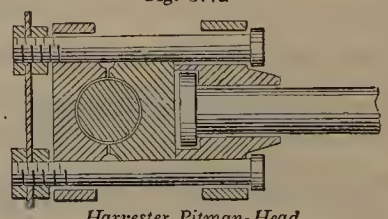
determinate freedom of motion is allowed in a plane coincident with its points of suspension and also transverse thereto.

Fig. 3772 is another form in which the head of the pitman is connected by swivel-pieces to the parts holding the boxes of the wrist to secure freedom of motion.

In Fig. 3773, the chilled-box pitman-head has an internal screw to receive the threaded end of the pitman, which is secured by a jam-nut.

Pi-tot's' Tube. A current-meter. It is a tube

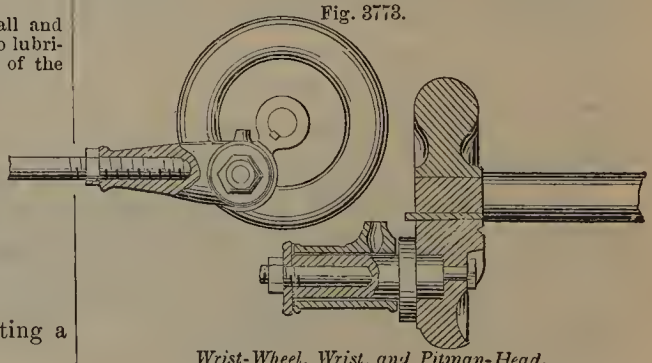
Fig. 3772



Harvester Pitman-Head.

open at both ends and bent at right angles. The longer leg is graduated and held vertically while the

Fig. 3773.



Wrist-Wheel, Wrist, and Pitman-Head.

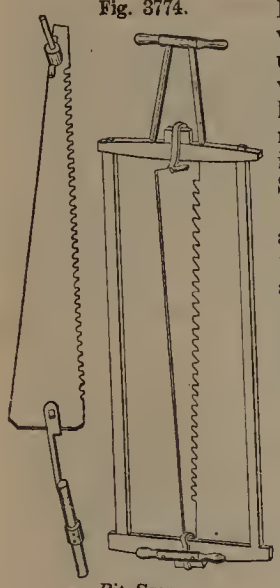
PIVOT BRIDGE OF THE AMSTERDAM, UTRECHT, AND COLOGNE RAILWAY.

OVER THE YSSEL, NEAR WESTERVOORT, HOLLAND.

PLATE XLI

See page 1721.

Fig. 3774.



Pit-Saw.

lower end is plunged in the water, the mouth pointing up stream. The rising of the water in the tube, above the level of the outside, is the measure of the force, that is, speed of the current. See CURRENT-METER.

Pit-saw. A saw operated by two men, one of whom stands on the log and the other beneath it. The place of the latter is frequently in a pit, and thence the name.

Pit-work. The pumping and lifting apparatus of a mine-shaft.

Piv'ot. 1. (*Machinery.*) A short shaft or pintle on which a body oscillates or revolves.

A bearing-pin of a small shaft.

2. (*Watchmaking.*) A journal at the end of an arbor. The workman uses special tools, known as the pivot-*drill*, pivot-*broach*, pivot-*file*.

Piv'ot-bolt. (*Ordnance.*) The axis of horizontal oscillation. A traversing platform passing through the pivot transom and the front sleeper of the platform.

Piv'ot-bridge. One form of swing-bridge, which moves on a vertical pivot beneath its midlength.

Fig. 3775 shows a number of forms of drawbridges.

a is a swinging span made up of panels of trusses.

b is a span on the Bollman principle across the Mississippi at Quincy, Illinois.

c is a pivot-bridge of the New York Central Railway on the Linville principle.

d is a swinging bridge on the Linville principle; it is one span of several across the Missouri River.

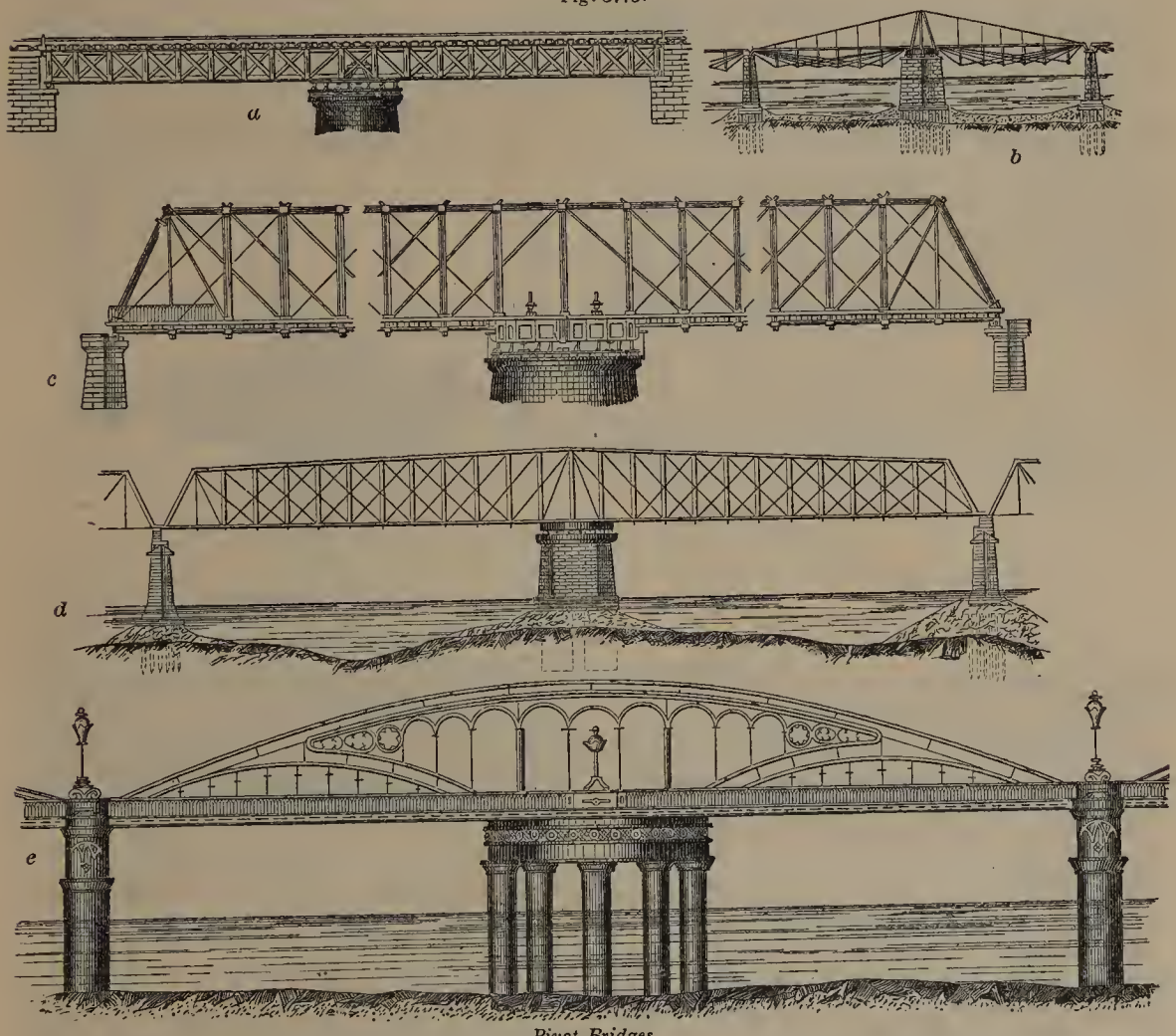
e is a bridge on the bowstring principle across the Harlem River, New York.

Plate XLI. is a view of the Swing Bridge of the Amsterdam, Utrecht, and Cologne Railway, over the Yssel near Westervoort, in Holland. It shows the swinging span, gatekeeper's house, land spans for carrying off water at spring floods, ice-breakers in the stream and on the lowlands. In the distance are the dunes of the coast.

Piv'ot-broach. (*Watchmaking.*) A fine broach or tool for opening the pivot-holes of watches.

Piv'ot-drill. (*Watchmaking.*) A bow-drill used in making the pivot-holes in plates of watches.

Fig. 3775.



Pivot-Bridges.

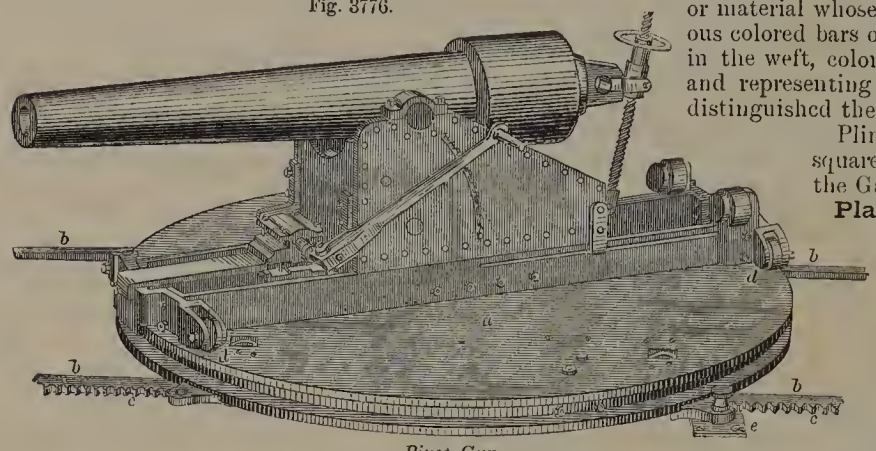
Piv'ot-file. (*Watchmaking.*) A fine file used in dressing pivots on the arbors of watches.

Piv'ot-gear'ing. (*Gearing.*) Cog-wheels so arranged that the axis of the driver may be shifted, to allow the machine — a threshing-machine, for instance — to be set in any direction from the power.

Piv'ot-gun. A gun mounted on a carriage which may be revolved so as to sweep all points of the compass. Usually employed on shipboard, but sometimes in fortifications.

Fig. 3776 shows a Parrott gun mounted on a pivot-carriage adapted to be shifted from side to side of a vessel, so that one

Fig. 3776.



Pivot-Gun.

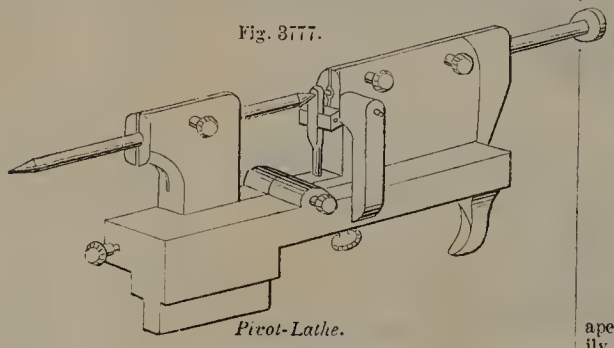
battery may answer for both broadsides. The carriage is in use on the thirty gunboats built for the Spanish government in New York, about 1870, and has since been adapted for other vessels. It was invented by Ericsson

The platform *a* runs on tracks *b b* across the deck of the vessel, and may be propelled by a cog-wheel gearing in the rack *c* on one of the tracks The carriage proper is pivoted in the center of the platform, and rests on wheels *d d*. When in firing position the platform is fastened to the deck by pins, one of which is shown at *e*.

Piv'ot-lathe. A small lathe used by watchmakers for turning the pivots on the ends of arbors for watch-movements.

In the example, the staff on which the pivot is to be turned is sustained in a laterally adjustable rest, with an axial support in the rear; the head which supports the spindle of the cut-

Fig. 3777.



Pivot-Lathe.

ting-tool is adjustable laterally: the shank of the burnisher is socketed in a transversely adjustable rest.

Piv'ot-tooth. (*Dental.*) An artificial crown attached to the root of a natural tooth by a dowel-pin of wood or metal occupying the nerve-canal, which is enlarged by a *broach* for that purpose.

Piv'ot-tran'som. (*Ordnance.*) The front member of the chassis.

Pix. (*Coining.*) A box in which are placed samples of coin for assay. *Pyx.* See COINING; REMEDY.

Place-brick. A name given in England to the imperfectly burned bricks at the outer part of a kiln or clamp. They are inferior in hardness and durability. Called also *pecking-brick, sandal-brick, samel-brick.*

Pla-cen'ta-for'ceps. (*Surgical.*) A forceps for grasping and extracting the afterbirth.

Pla-cen'ta-hook. (*Surgical.*) A small, round pointed hook with ebony handle, used in obstetrics, to extract the afterbirth.

Place-of-arms. (*Fortification.*) Enlargements in the salient and reëntering angles of the *covered way*, and serving for the occupation of the troops who defend it. See BASTION.

Plaid. (*Fabric.*) Goods of any quality or material whose pattern consists of various colored bars or stripes in the warp and in the weft, colored in the wool or thread, and representing the Scotch tartans which distinguished the clans.

Pliny states that to divide by squares in weaving came from the Gauls.

Plain-back. (*Weaving.*) *a.* The ground on which the *nap* or *pile* is raised.

b. Bombazette.

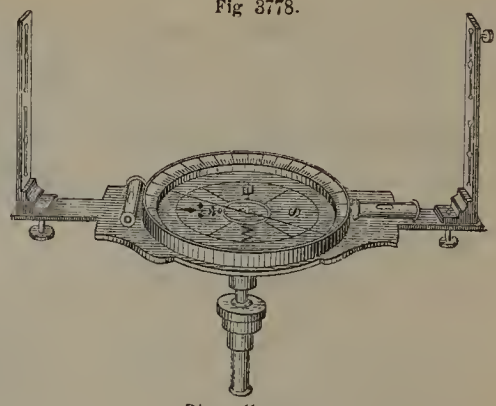
Plain Cloth. (*Fabric.*) Not twilled.

Plain-com'pass. A simple form of the surveyor's instrument. It has a needle about six inches long, a graduated circle, main plate, levels and sights, and is placed upon the brass head of the *Jacob-staff.*

The compass-circle is divided to half-degrees on its upper surface, the whole degree marks being also cut down on the inside circumference, and is figured from 0 to 90 on each side of the center or "line of zeros."

The sights, or standards, have fine slits cut through nearly their whole length, terminated at intervals by large circular

Fig. 3778.



Plain-Compass.

apertures through which the object sighted upon is more readily found.

The right and left hand edges of the sights have respectively an eye-piece, and a series of divisions, by which angles of elevation and depression, for a range of about twenty degrees each way, can be taken with considerable accuracy. This arrangement is termed a *tangent-scale*, the divided edges of the north sight being tangents to segments of circles having their centers at the eye-pieces and their points of contact with the tangent lines at the zero divisions of the scale.

Plain-gauze. (*Weaving.*) Worked without flowers.

Plain-mold'ing. (*Joinery.*) Molding of which the surfaces are plane figures.

Plait. 1. Braid.

2. A flat fold in a garment, as on a shirt-bosom.

3. Straw-plait is made in various ways, and after a variety of patterns, known by the name of the place whence it is brought, as *Leghorn, Tuscan, Dunstable;* or by the number of strands, as *seven, double-seven;* or by other characteristics, as *split, vandyke, open,* etc.

The straws are carefully selected, cut into equal

lengths, bleached by exposure to sulphur fumes, split lengthwise, and plaited together, according to the taste and the market.

The Leghorn, for instance, is a 13 plait, 6 straws being turned to the left and 7 to the right, so as to cross each other at right angles; the outer one of the seven is turned down, under two, over two, and under two; the outer straw on the other side, which now has seven, is next turned down, passing below, above, and below, in the same manner.

Straw is split by a wire which has a series of sharp edges equal in number to the number of splits into which it is desired to divide the straw. The slips are softened in water to render them pliable in plaiting. The plait is flattened between wooden rollers.

4. (*Nautical.*) Strands of rope-yarn twisted into *foxes*, or braided into *sennit*.

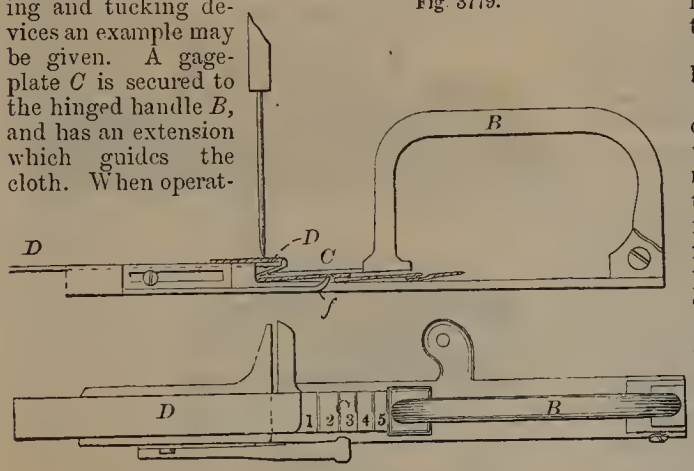
Plait'ed Rope. A flat rope made by plaiting instead of twisting. *Sennit.*

Plait'ing. 1. (*Hat-making.*) The interweaving of the felted hairs, forming a hat-body by means of pressure, motion, moisture, and heat. Also called HARDENING (which see).

2. Interweaving of strands to form a flat rope or braid.

Plait'ing-at-tach'ment for Sew'ing-ma-chines'. A plait is a flattened gather or fold. Of the numerous plaiting and tucking devices an example may be given. A gage-plate *C* is secured to the hinged handle *B*, and has an extension which guides the cloth. When operating, the gage-plate rests upon the cloth and pushes it against a shoulder, above which the folding-plate *D* is secured. An adjustable guide *f* causes the tuck which is just formed to be fed in a line parallel to the plait which is being stitched.

Fig. 3779.



St. John's Tucker.

Plan. A map or representation of a building or machine on a given plane. A horizontal section at a specified level.

1. In architectural drawing, the term is applied either to a *ground plan*, the *orthography*, or to a horizontal section at a given hight, say one of floors or stories.

In the *geometrical* plan, the parts are represented in their natural proportions.

In the *perspective* plan, the lines follow the rules of perspective, reducing the sizes of more distant parts.

Other views are *elevations, end* or *side*, and *sections;* also called *raised plans.*

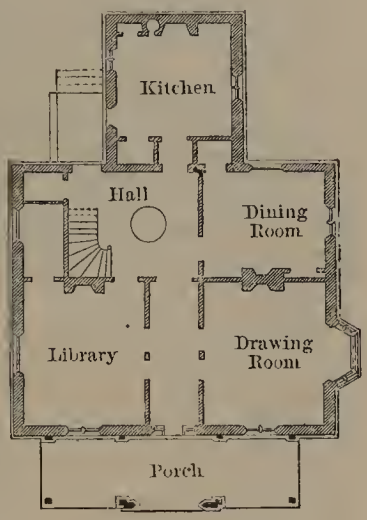
2. In shipbuilding, the term *plan* is of more general import, and we have —

a. The *shear-plan*, giving the lines of horizontal sections at different hights, as well as the bow and buttock lines, which represent the boundaries of vertical sections in planes parallel to the vertical longitudinal section. The shear-plan is practically a side elevation or longitudinal view.

b. The *half-breadth plan* is practically a top view of one half of the vessel, divided vertically and longitudinally in the line of its keel. It is a *plan* in the more restricted sense.

c. The *body-plan* is an end elevation, showing the *water-lines, buttock and bow* lines, *diagonal* lines, etc. See LINE.

Fig 3780.



Plan of a Cottage.

Plan'ceer. (*Architecture.*) A SOFFIT (which see).

Planch. An iron shoe for mules.

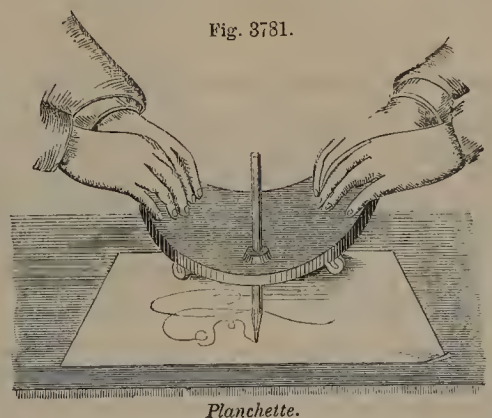
Plan'chet. (*Coining.*) A flat disk of metal. A round disk of metal weighed and tested is a planchet ready for coining.

The strips of plate from which planchets have been removed are called *scissel.*

Plan-chette'. 1. A heart-shaped piece of board mounted on thin supports, two of which are casters, and one a pencil which makes marks as the board is pushed under the hands of the person or persons whose fingers rest upon it. The exact cause of its motions is not clearly understood, as a portion seems to be involuntary on the part of the performers.

Planchette belongs to the family of so-called "spirit-manifestations," table-tippings, etc. These and similar phenomena have not been satisfactorily explained; and thus far they seem productive of more harm than good, where accepted as genuine manifestations of disembodied spirits.

Fig. 3781.



Planchette.

In principle it is as old as the hills. The Chinese know all about it. When they would consult a god, they set before the image a platter of sand, and two men grasp one leg each of a V-shaped piece of wood, the point of which rests on the sand. The spirit of the god is supposed to descend and move

the marker, and the marks it makes in the sand are translated into an oracular answer!

While the pursuit of such knowledge has been the destruction of the religious faith of thousands, and while the pursuit of the exact and speculative sciences has, in many cases, crowded out all belief in the supernatural, it is a comfort to some of us to read the testimony of the great physicist Faraday: "I have never seen anything incompatible between these things of man which can be known by the spirit of man which is within him and those higher things concerning his future which he cannot know by that spirit."

2. A circumferentor.

Plane. 1. (*Woodworking.*) A carpenter's cutting and surface-smoothing tool, of which there are many varieties, called from some peculiarity of construction or purpose.

A tool having a bit-iron set in a flat-soled stock, and used for smoothing surfaces by taking thin shavings therefrom.

The *bit* is known as the *iron*.

The *iron* is fastened in the *stock* by the *wedge*, which holds it to the slanting surface known as the *bed*. The *abutment* is the shoulder, between which and the plane-bit the wedge is driven.

The bottom of the *stock* is the *sole*.

The *toat* is the handle.

"The shavings of fir, when briskly *planed*, always curl up in circles like the tendrils of the vine." — PLINY.

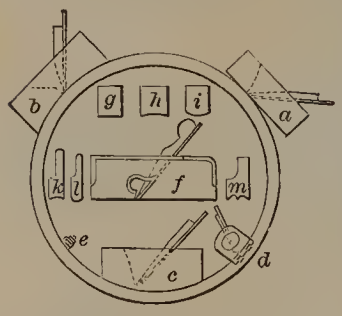
The plane of the Romans was known as *runcina*.

The Japanese planes are small, with single irons, — no handles. The planes are shorter, lighter, and the wood shallower than ours, being generally not more than an inch deep. To plane a piece of wood, they lay it on the ground, squat on their hams, hold it fast with their toes, and work the plane by drawing it with both hands toward them.

Some of their tools appear to be mere children's toys; for instance, they have a smoothing-plane two and one half inches long, one inch broad, and half an inch thick

In Fig. 3782, *a* shows a flat solid plane applied to a curved exterior surface; the rounding can, however, be effected more speedily and conveniently by the concave plane *b*. The compass-plane *c* is adapted for curved interior surfaces, and may be used for forming curves having a greater radius than its sole. *d* is a plane for the hand-rails of staircases; *e*, spokeshave; *f*, bench-plane; *g*, section of stock of bench-plane; *h*, *i*, *k*, *l*, *m*, sections of molding-planes.

Fig. 3782.



Planes (Diagram showing the Kinds).

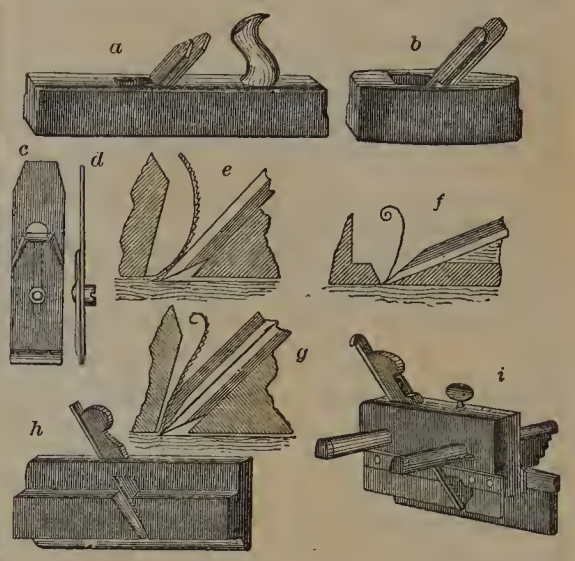
In Fig. 3783, *a* is a jack-plane; *b*, smoothing-plane; *c*, *d*, double plane-iron, the shorter is termed the *break-iron*. *e* illustrates the action of a plane in which the mouth has become much worn; the shavings are comparatively unbroken, and the iron, splitting the fibers, does not give a smooth surface. *f*, mouth of *miter-plow*, of small aperture, faced with metal and effecting a comparatively smooth cut; this object is better effected by the double plane-iron, as shown at *g*; *h*, fillister; *i*, plow.

In Smith and Carpenter's plane (*A*, Fig. 3784), the stock is stiffened by an upper metallic frame; the plane-iron *a* is held between the wedge *b* and curved branch *c*, and is adjusted by a thumbscrew *d*.

Evans's plane-stock *B* consists of a metallic piece *a*, in which the bit is secured by a lever *b* provided with a thumbscrew; curved arms *c c*, to which the flexible sole *d* is attached, work in slots at the ends of the stock; the sole may thus be adjusted to any desired curve within certain limits, the arms being secured by the screws *e e*.

The stock of Buckel's plane *C* is made in two parts, pivoted together at *a* through metallic guide-plates on each side. A spring *b* is interposed between the two parts at front, their distance apart being regulated by the screw *c*. The plane-iron is fixed in the upper part, and is caused to protrude more or less from the mouth, according to the downward pressure exerted by the hand; the depth of cut may thus be varied at each stroke, and the drag of the bit as the plane is drawn back is prevented.

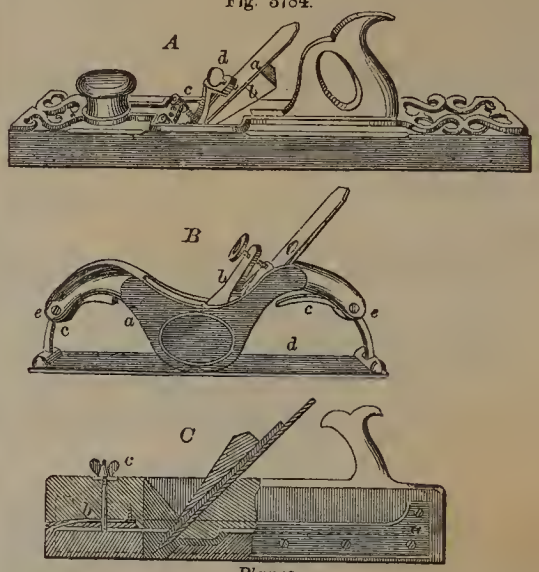
Fig. 3783.



Planes.

An American plane, patented in 1832, has a thumbscrew on the top iron, which moves two lateral pins fitting in grooves in the sides of the plane. The plane-bit being adjusted to the required position, rotation of the thumbscrew tilts the top plate, which bears against the bit and holds it in place without a wedge.

Fig. 3784.



Planes.

The following are the dimensions of some of the more common varieties of planes: —

	Length in Inches.	Width in Inches.	Width of Irons.
Modeling-plane	1 - 5	¼ - 2	3/16 - 1½
Smoothing-plane	6½ - 8	2⅜ - 3⅛	1¾ - 2⅜
Rabbet-plane	9½	⅜ - 2	⅜ - 2
Jack-plane	12 - 17	2½ - 3	2 - 2¼
Panel-plane	14½	3½	2½
Trying-plane	20 - 22	3¼ - 3⅜	2⅜ - 2½
Long-plane	24 - 26	3⅝	2⅝
Jointer-plane	28 - 30	3¾	2¾
Cooper's jointer-plane	60 - 72	5 - 5¼	3½ - 3¾

The angle of the bit varies with the work; the harder the wood the steeper the pitch.

Common pitch is 45°, and *half-pitch* is 60°. There are other pitches between the two. See PITCH.

See under the following heads: —

Angle-plane.
Astragal-plane.
Badger-plane.
Banding-plane.
Bead-plane.
Bench-plane.
Border-plane.
Break-iron.
Capping-plane.
Carpenter's plane.
Compass-plane.
Concave-plane.
Cooper's plane.
Core-box plane.
Cornice-plane.
Counter-check.
Covetta.
Cutting-plane.
Cutting-thrust.
Dovetail.
Dovetail box-plane.
Edge-plane.
Fillet-plane.
Fillister.
Fluting-plane.
Fore-plane.
Forkstaff-plane.
Grooving-plane.
Hand-rail plane.
Hollows and rounds.
Hollow-sash plane.
Howel.
Ice-plane.
In-shave.
Jack-plane.
Joiner's plane.
Jointer.
Jointing-plane.
Lamb's-tongue.
Loug-plane.
Matching-plane.
Metal-plane.
Miter-plane.
Modeling-plane.
Molding-plane.
Ogee-plane.
Overshave.
Ovolo-plane.
Pauel-plane.
Panel-plow.
Pistol-router.
Plane-guide.
Plane-iron.
Plane-table.
Plow.
Quarter-round.
Quirkiug-plane.
Rabbet-plane.
Reed-plane.
Reglet.
Rounding-plane.
Round-nose plane.
Router.
Sash-fillister.
Sash-plane.
Scaleboard-plane.
Scraping-plane.
Shooting-plane.
Side-fillister.
Side-plane.
Side-rabbet plaue.
Side-round plane.
Side-suipe.
Single and three reed planes.
Skew-plane.
Skew-rabbet planc.
Slat-plane.
Slitting-plane.
Smoothing-plane.
Suipe-bill planc.
Splint-planc.
Spokeshave.
Spout-plane.
Square-rabbet plaue.
Stock-shave.
Sun-plane.
Table plane.
Tonguing-plane.
Toothing-plane.
Try-plane.
Whisk.
Witchet.

2. A straight surface; a "true plane" is a gage or test of flatness. The "true" planes exhibited by Whitworth at the Paris Exposition were polished metallic surfaces of 100 inches area. These were prepared in triplets, to avoid the error which may occur, as, when ground together, one might become convex and the other concave, but a third could not possibly fit both unless they were all correct. The error is said not to have exceeded the $\frac{1}{1000000}$th of an inch. One slides over the other as freely as upon ice, until, by pressure, the film of air is removed, and then the adherence is so strong that one is readily lifted by the other. See PLANE-SURFACE.

3. (*Fortification.*) *Plane of defilade;* a plane passing through the crest of a work parallel to the plane of site.

Plane of site; the general level of the work, horizontal or inclined.

Plane-ash'lar. (*Masonry.*) Ashlar with smooth-worked face.

Plane-bit. The cutter of a plane; generally termed the *plane-iron.* The cutting-edges of plane-irons are generally a right line, but, for some purposes, they are made with rectangular or curved grooves. They are set in the stock at various angles with the sole, 45° being termed *common pitch:* this is employed in bench-planes for soft woods; 50°, *York pitch,* for mahogany and hard woods; 55°, *middle pitch,* is used in molding-planes for soft woods, and smoothing-planes for mahogany and hard woods; 60°, *half pitch,* in molding-planes for hard woods. The iron rests on the *bed,* and is held between this and the abutment by a wedge which adjusts its projection beyond the mouth. In metal-workers' planes the iron is set at an angle of 70° or 80°; it is adjusted by a vertical screw, and an end screw and block is substituted for the wedge; its face is frequently grooved, giving a greater penetration, the smoothing being afterward effected by a plane with a narrow bit.

Double irons are generally employed in the better class of planes; the upper, called the *break-iron,* does not cut, but breaks the shaving, allowing the lower bit to effect a smooth-cutting action without splitting the wood.

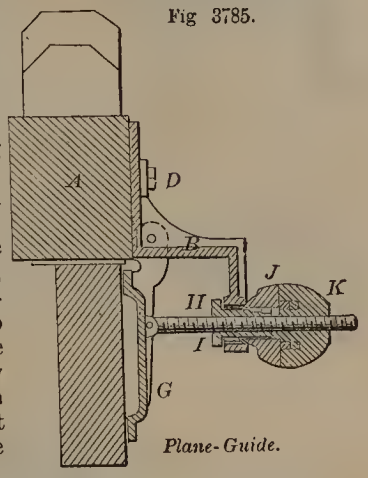
The *scraping-plane,* having its bit perpendicular or nearly so, is also employed on hard wood and ivory; with its edges serrated, such a plane is used by cabinet-makers for roughing veneers and the surfaces to which they are glued.

The width of plane-irons varies according to kind.

Modeling-planes	$\frac{3}{16}$ – $1\frac{1}{2}$ inches.
Smoothing-planes	$1\frac{3}{4}$ – $2\frac{3}{8}$ "
Rabbet-planes	$\frac{3}{4}$ – 2 "
Jack-planes	2 – $2\frac{1}{4}$ "
Panel-planes	$2\frac{1}{2}$ "
Trying-planes	$2\frac{3}{8}$ – $2\frac{1}{2}$ "
Long-planes	$2\frac{3}{8}$ "
Jointer-planes	$2\frac{3}{4}$ "
Cooper's jointer-planes	$3\frac{1}{2}$ – $3\frac{3}{4}$ "

Plane-guide. (*Joinery.*) An adjustable attachment used in beveling the edges or ends of plank. Woodville's (Fig. 3785) is secured to the stock *A* by screws *D,* passing through slots in the plate *B* hinged to the plate *G,* which rests on the face of the board; the desired inclination is given to the sole of the plane by the screw *H* working through the threaded nut *I,* and held by the jam-nut *J K.*

Fig 3785.



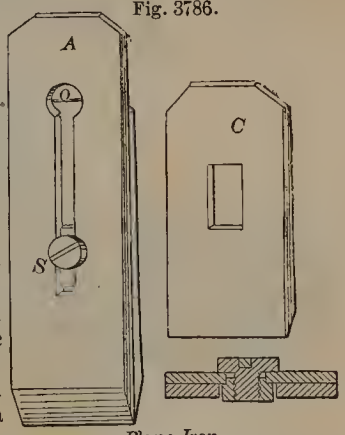
Plane-Guide.

Plane-i'ron. The cutting-iron inserted in a plane-stock and fastened by a wedge. Names indicate structure or function, as —

Double plane-iron.
Break-iron.
Top plane-iron.
Round-nose plane-iron.
Toothed plane-iron.
Smoothing plane-irou.

See PLANE; PLANE-BIT.

Fig. 3786.



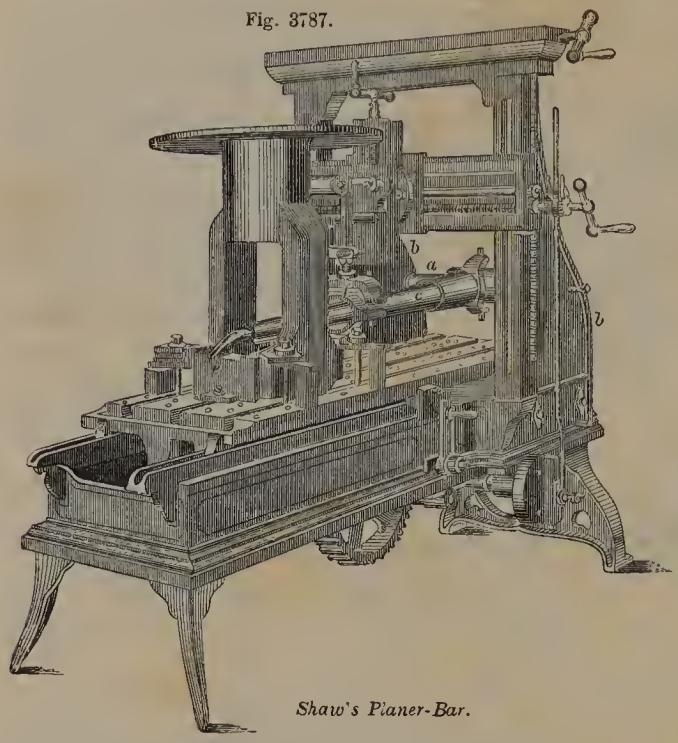
Plane-Iron.

A, plane-iron. *C,* cap.
S, coupling-screw; a slot.

Plan'er. (*Printing.*) A wooden block used to even the face of a form of type before printing; the top usually covered with leather to deaden the blow of the mallet.

Plan'er-bar. A device attached to a planer for the purpose of effecting in part the work of a slotting or shaping machine. Shaw's (Fig. 3787) consists of a transverse cylinder *a* journaled in the standards *b b*; the bar *c* is pivoted to *a* at *d,* forming a universal joint, and allowing the tool *e* to be presented in any direction, within certain limits, to the work on the bed beneath. At *f* is a pivoted box, which is fastened by a pin to the tool-post and carriage, in the feed-motion of which the tool *e* consequently participates. The illustra-

Fig. 3787.

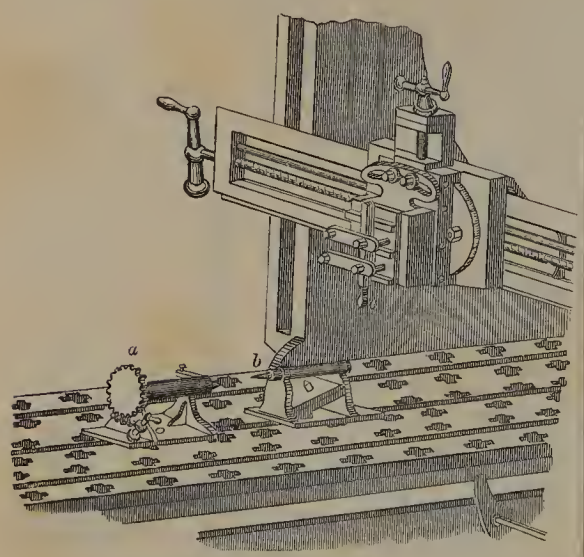


Shaw's Planer-Bar.

tion shows the tool operating on the interior of a large casting.

Plan'er-cen'ters. Devices similar to lathe-centers for supporting small work on the bed of a planing-machine. One of the two (*a b*, Fig. 3788) is provided with a worm and worm-wheel, by which the work may be rotated, so as to present each face

Fig 3788.



Planer-Centers.

in succession to the cutter *c*; the other has an inclined plane, by which the slope of the work is regulated so as to give a taper, if required.

Plane-stock. (*Joinery.*) The body of the plane in which the iron is fitted. See PLANE.

The *sole* or *face* is the flat lower surface.

The *iron* is the cutting piece.

The *wedge* holds the iron upon the slanting portion, called the *bed*.

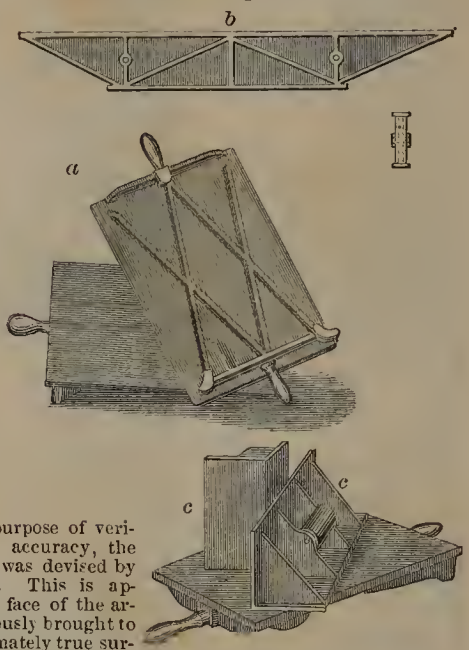
The plane-iron projects through the *mouth*, through which also pass the shavings.

A *horn* is a projecting piece at the fore end.

A *handle* or *toat* is at the rear end, to push by.

Plane-sur'face. Plane-surfaces are produced by the planing-machine, by the file, and by grinding, using an abradant.

Fig. 3789.



Plane-Surfaces.

For the purpose of verifying their accuracy, the *planometer* was devised by Whitworth. This is applied to the face of the article, previously brought to an approximately true surface, and thinly coated with red-lead in oil, which will be transferred, in those parts which are too high, to the planometer. These must be reduced by filing or grinding until the surface of the work coincides in every part with that of the planometer; this is the case when the pigment is transferred equally to the face of the testing-plane.

In Fig. 3789, *a* represents this instrument. Its back is strengthened by ribs, which have three feet, so that it may rest even on the table or work-bench.

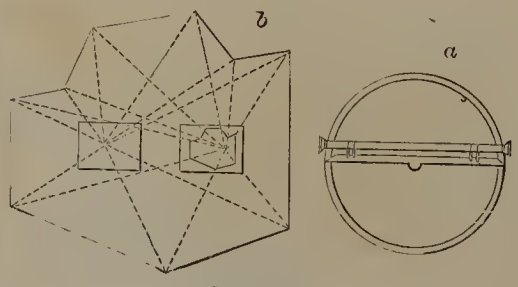
b is a straight-edge, similarly stiffened by vertical and diagonal flanges extending from one to the other of its parallel sides.

c c are angle-plates, made to form a true right angle at the edges and ends, so that by placing the work on a surface-plate, its external angles may be tested.

d is a square with wide faces, and having braces set at angles of 60° and 45°, respectively. The stops *e e* may be set so as to project beyond the square, and be applied to the edge of the work, or turned out of the way, leaving the side of the square flat. A *planometer*.

Plane-ta'ble. An ancient instrument for taking angles in mapping. The round table *a* is adapted to receive sheets of paper, and has a marginal, graduated circle. Over the center of the table an alidade

Fig. 3790.



Plane-Table.

is pivoted, one side of the alidade intersecting the center and reaching to the marginal graduations. The telescope being directed in turn to the different objects to be observed, a line is drawn on the table which represents the direction to the said objects from this station. Another station is then selected, and the distance between the two carefully measured. The telescope is then pointed to the same objects in turn from the new station, and the lines of direction marked on another sheet of paper. The two triangulations being placed on a plotting-table at the proper distance between stations, on the required scale, the lines of direction from each station are prolonged, and their intersections give the angles, as in figure *b*, which is supposed to be a fort whose angles are all distinguishable objects, and whose sides are straight lines between the said angles.

Würdemann's plane-table is a geodetical instrument consisting of two main parts: (1.) The motion works on a tripod, including leveling-screws and a horizontal movement, with clamp and tangent, above which is fastened down the drawing-board, which receives the paper. (2.) On this is placed the alidade, consisting of a broad metallic ruler with level, an upright column, near the middle, carrying above a telescope on a horizontal axis, so as to have a vertical movement of about 30° each way from the horizontal position. The telescope itself is accurately adjusted parallel to the ruler's edge. A vertical divided arc of 30° each way, with vernier reading to minutes, is commonly added for determining altitudes. The plane-table is used altogether for details of surveys, such as roads, shore lines, borders of forest, houses, etc. It differs from all other instruments in the results of the work, that it produces immediately a detail map in the field, whilst going over the ground, measuring distances, and triangulating within the limits of the sheet on the board according to the scale of reduction required. A telemeter rod or chain is used in connection with it.

Plan'et-a'ri-um. A machine for exhibiting the relative motions of the planets and their positions in respect to the sun and one another, sometimes rather absurdly called an *orrery*.

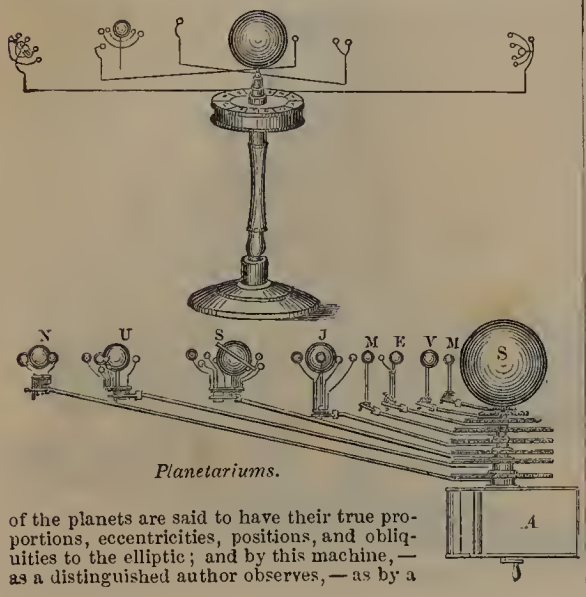
A planetarium made by Graham, the renowned mechanician and watchmaker, came into the possession of the Earl of Orrery and obtained celebrity. It received its name from Steele, who wrote a description of it.

The first recorded *planetarium* was made by Archimedes, about 200 B C. It must have been constructed after the geocentric system, which then obtained, — the earth in the center, and so on.

A *planetarium* constructed at Florence in the fifteenth century is described in a letter from Angelo Politiano to his friend Francesca Casa. It illustrated the Ptolemaic system, the received theory of the time.

The planetarium of Huyghens, preserved in the University of Leyden, showed the revolution of the primary planets about the sun, and that of the moon round the earth, performed in the exact times actually occupied in those motions. The orbits

Fig. 3791.



Planetariums.

of the planets are said to have their true proportions, eccentricities, positions, and obliquities to the elliptic; and by this machine, — as a distinguished author observes, — as by a perpetual ephemeris, the situations, conjunctions, and oppositions of the planets for any time may be accurately determined.

We read of a *planetarium* by Watson, in 1689, and another constructed by Rowley, 1700, from the plan of Graham. This was the one referred to above as having come into the possession of the Earl of Orrery, and is similar to the upper one in the accompanying figure.

Sir John Herschel says: "As to getting correct notions on the magnitudes and distances of the planets by drawing circles on paper, or, still worse, from those very childish toys called orreries, it is out of the question."

With great deference to the distinguished astronomer, we must insist upon the use of orreries, not for showing magnitudes and distances, but for exhibiting the relational positions and explaining celestial phenomena.

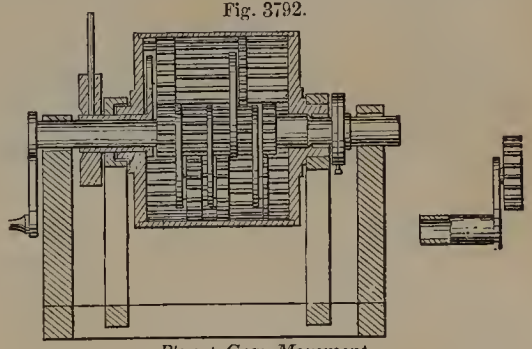
Dr. Desaguliers described a complete *planetarium* in his "Course of Experimental Philosophy," published in 1734.

A very complete apparatus of the kind was a planetarium shown in London in 1791, and purchased by the English government in 1793, to be sent out with Lord Macartney on his embassy to China, as a present to the emperor of the Celestial Flowery Land. It was said to have been ample and scrupulously correct. Whether the English and French mashed it when they sacked Pekin, about seventy years afterward, we do not know.

In the lower planetarium (Fig. 3791), the globe representing the sun is supported on a central shaft, around which are arranged a series of sleeves, corresponding in number to the planets of the solar system. The shaft supporting the sun is caused to rotate in a time relatively corresponding to the diurnal revolution of that luminary, and the sleeves which carry the tubes supporting the planets are also revolved in times proportionate to their revolutions around the sun by wheels meshing with gears on a shaft within the case *A*, and provided with an exterior crank by which it is turned. The diurnal revolutions of the planets are caused by bevel-gearing on the sleeves and on rods within the tubular arms above mentioned, which rods also carry on their ends gears for causing the revolution of the satellites around their primaries.

Plan'et-gear. (*Gearing.*) That in which one or more cog-wheels besides rotating on their axes revolve around the wheel with which they mesh. In the example, which is a mechanical movement for gaining speed for the cutter-bar of a harvester,

Fig. 3792.



Planet-Gear Movement.

the inclosing cylindrical case is fixed and has an inside gear. A planet-wheel on an arm turning with the axial shaft engages the inside gear, and also a spur-wheel upon a sleeve turning loosely on the axial shaft. The latter sleeve has an arm carrying a planet-wheel. This device may be multiplied to any extent to convert power into speed.

Plane-tile. A flat tile, about $6\frac{1}{2} \times 10\frac{1}{2}$ inches and $\frac{5}{8}$ thick. It weighs from 2 to $2\frac{1}{2}$ pounds. It is fastened by two oak-pins, which pass through holes made in the tiles in the molding. Tiles are laid to a $6\frac{1}{2}$-inch gage; 740 cover 1 square, *i. e.* $10 \times 10 = 100$ square feet. A *crown*-tile.

Plan'et-wheel. The exterior revolving wheel of the "sun and planet" motion, invented by James Watt. So called from its rotation around another gear-wheel, which is termed the *sun-gear*. The axis of the planet-gear is preserved concentric with the axis of the central or sun wheel by means of an arm. The planet-wheel sometimes gears with an internally cogged

Fig. 3793.

Planet-Wheel.

wheel, and may be driven by the latter, rolling around inside the larger gear-wheel instead of outside. (See EPICYCLOIDAL WHEEL; SUN AND PLANET MOTION.) The action may be inverted, the larger wheel driving the smaller instead of being driven by it.

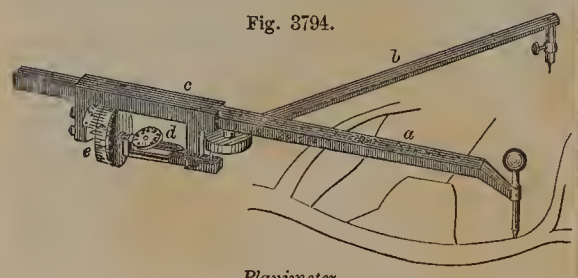
Pla-nim'e-ter. An instrument for ascertaining the contents of irregular plane figures.

More than thirty years ago, Oppikoffer, of Berne, invented an instrument of this description, which seemed to fulfill all the requirements of the case; but its cost and the practical difficulties attending its use prevented its general adoption.

More recently, Amsler Laffon of Schoffhausen devised a simpler and much less costly instrument of the kind, which was exhibited at the Paris Exposition of 1867. The principle of each is nearly the same, the area being measured by a roller of given surface, the number of revolutions of which are indicated by a disk.

Amsler's polar planimeter has a sliding arm *a* and a pivoted arm *b*, the former having a pin for penetrating the paper, and

Fig. 3794.



Planimeter.

the latter a tracing-point. The arm *a* is graduated to indicate acres, square inches, and square feet. In use, the needle-point is pressed into the paper into a point either within or without the figure; the arm *a* is adjusted by sliding in or out until the mark for acres, inches, or feet, as may be required, corresponds with a mark on the box *c*; the tracing-point is moved along the outlines of the figure until the point is reached at which it was started. If the stationary needle-point were placed without the figure, the readings of the counting-wheel *d* and index-roller *e*, subtracted from their readings at the commencement of the operation and multiplied by the indication to which the slide was set, give the area; if the stationary point be without the figure, a number opposite the indication on the slide is added to the final readings on the wheels *d e*, and the former reading subtracted therefrom; the difference is then multiplied, as before.

Other planimeters have been constructed by General Morin and by Mr. Sang. Sometimes called a platometer.

Plan'ing-ma-chine'. 1. (*Wood.*) A machine for truing up and facing boards or the sides of timbers. When it also works the edges, it is known also as an *edger;* when the edges are respectively tongued and grooved, they are known as *matched,* are said to be *matched up;* when the stuff is molded or dressed to ornamental shape, the machine is known as a MOLDING-MACHINE (which see).

Planing-machines for wood-working are of three general kinds, and will be mentioned in the order of their invention, not of their usefulness.

a. The *reciprocating* planing-machine was invented by General Bentham in 1791, its action being based upon that of an ordinary plane. It had a large plane or stock with inclined bits (plane-irons) which reciprocated on ways, planing down to a thickness the board which lay upon the bed beneath, the board being moved forward after each reciprocation of the plane, in order to expose a fresh surface to be worked. The plane-iron was the whole width of the board, and slips on the bed determined the depth of penetration. The plane was moved to and fro by a crank; it was held down to its work by weights, and was lifted above its work during the back stroke, to save the dulling of the cutter.

The *scaleboard plane* is of this character, and is used in cutting from boards or balks the wide chips used in making some descriptions of boxes, for veneer, and for other purposes. It has a plane-iron the width of the board, and the protrusion of the iron from the sole of the plane determines the thickness of the scale.

General Samuel Bentham's name is preëminent in the history of machines for working wood. See WOOD-WORKING MACHINES.

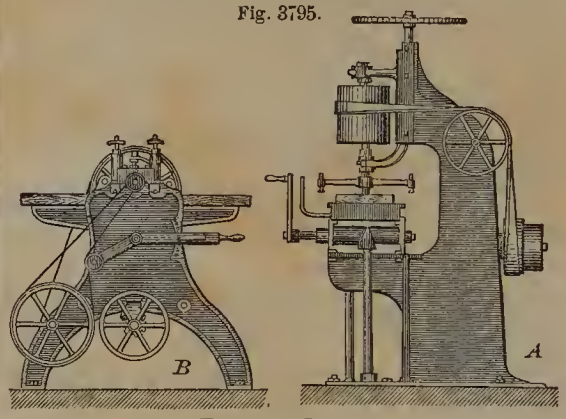
This plan has been again and again tried, but has not succeeded. It was probably the feature of Hatton's planing-machine, English patent, 1776.

It appears that subsequently General Bentham (brother of Jeremy) made molding-machines with rotary cutters, and also planing-machines to dress both sides at once.

b. The *transverse* planing-machine was invented and patented by Bramah, in 1802. It has a horizontal roughing-wheel armed with gouges, followed by plane-irons for finishing. It is known also by the name of the *Daniels planing-machine.*

A, Fig. 3795, is a view of a machine of this kind by Richards of Philadelphia. As shown, it is especially adapted for pattern and car shops; is wholly of metal, including the carriage, which is planed true, moves on anti-friction rollers, and is provided with

Fig. 3795.

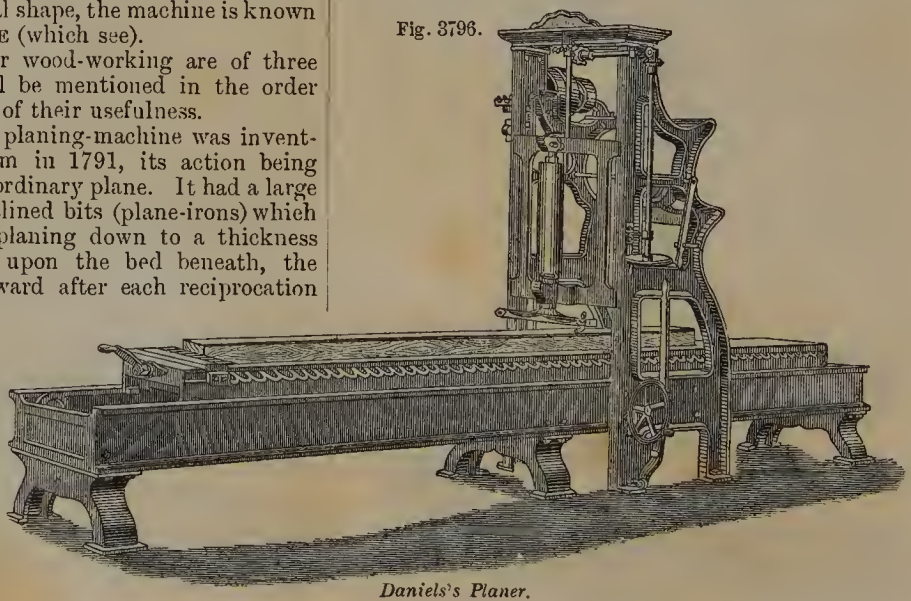


Transverse Planer.

end and side clamps that will hold pieces 15 inches wide, 6 inches thick, and 6 or more feet in length, or as small as 1 inch square. See also TRANSVERSE PLANER.

The clamps and all the adjustments are so arranged as to be instantly changed for pieces of various sizes. The feeding movement is performed by hand. This admits of a rapid manipulation of the machine, modifies the feed to suit the work, and allows the operator to feel the action of the cutters. The driv-

Fig. 3796.



Daniels's Planer.

ing-pulleys can be arranged so that the machine will stand either parallel with or transverse to the line-shaft; a counter-shaft being required in the first case. The cutter-head is of wrought-iron, the spindle of steel, and the bearings of brass. The framing, being open on the front, gives easy access to the cutters, and admits pieces of any width. The operator is protected by an iron shield in front of the cutters.

In Bramah's machine, as used in the gun-carriage department of Woolwich Arsenal, England, the boards passed beneath a disk-wheel which rotated on a vertical spindle, and had 28 gouges and 2 plane-irons on its lower face. The lumber traversed on either of two beds, one on each side of the spindle, the feed being by means of a continuous chain which passed over pulleys at the ends of the tracks. The cutter-wheel was large, and revolved 90 times in a minute.

Fig. 3796 is a view of the Daniels planing-machine, made by Fay & Co., Cincinnati, Ohio. Instead of the wheel with 28 gouges and 2 double-irons of the original Bramah, it has a pair of arms, each carrying a cutter. The timber to be dressed is dogged to a sliding carriage, the feed being automatic and adjustable as to rate. The cutter is driven by a band upon the roller on the vertical shaft of the cutter; this portion of the machine being in a gate, which has a vertical adjustment in the standards of the frame, so as to determine the level on which the cutter shall work.

c. The *cylinder planing-machine.* This is now the usual machine. It has cutters on a drum rotating on a horizontal axis over the board which passes beneath. The cutter-drum is the width of the board, and may be repeated underneath and at the edges, so as to plane top, bottom, and edges simultaneously. In some cases, the board travels on its edge.

An early form of this was Muir's planing-machine for facing flooring-boards. It had rotary cutters above and below, two oblique fixed cutters to smooth the faces, two cutters to make the sides parallel, and two others to make the rabbets which form a tongue.

The Woodworth planing-machine, patented in 1828 and twice extended, became an odious monopoly, and did much to discredit the patent system. It claimed the combination of cutting-cylinders and feeding-rolls. Cutting-cylinders were used by Bentham thirty-five years before, and rollers for feeding lumber to circular saws were described in Hammond's English patent, 1811.

Richards's roller-feeding planing-machine (*B*, Fig. 3795) is a small machine of the cylinder class, adapted for preparing lumber for pattern-makers and others. As shown, it is constructed to plane from ¼ to 5 inches thick and 20 inches wide; has a wrought-iron cutting-cylinder, wrought-iron feeding-rollers, and cylinder-bearings of brass.

The planing-machine (Fig. 3797) may be taken as an example of its class. It has an iron frame, will plane 24 inches wide, and match up to 12 inches. It has a three-knife steel-lipped cylinder for facing, and triple-sided gun-metal matcher-heads. It planes up to 4 inches thick.

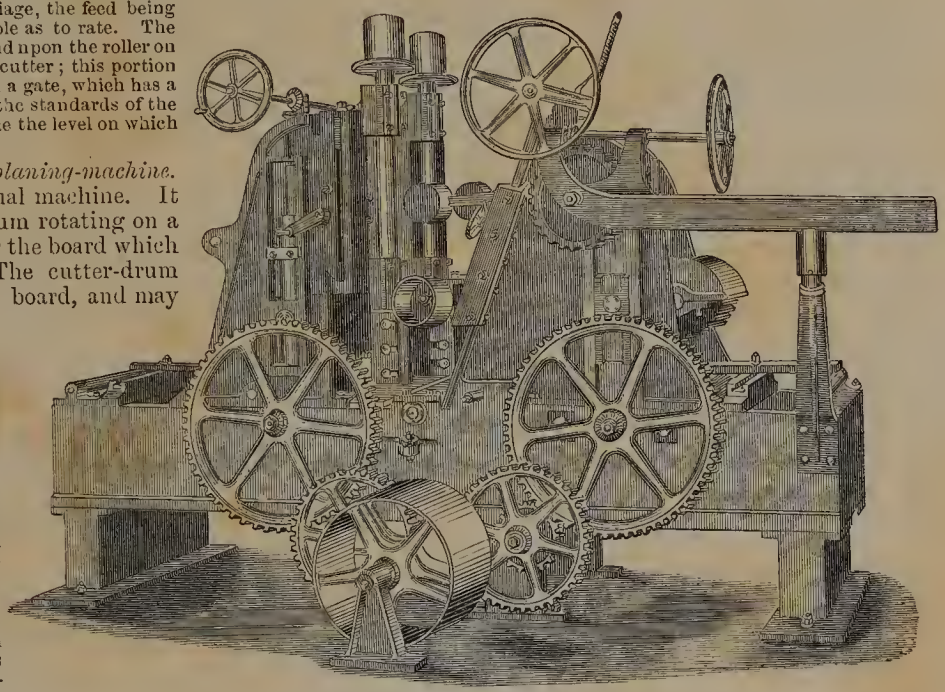
This form of planing-machine, with peculiarly shaped cutters, constitutes a MOLDING-MACHINE (which see).

The *outside* molding-machine is one in which the head overhangs the bearing.

The *inside* molding-machine has its cutter-head between bearings.

Fig. 3798 is a view of Richards's planing-machine for dressing to shape and dimensions, timbers for cars, machines, bridges, etc. It planes true and out of wind three sides at a time, the working side being previously dressed to lie upon the carriage of the machine. It has a cross cylinder-cutter for the top, and two vertical cutters for the sides, with in and out adjustment for the latter and up and down adjustment for the former so as to dress to any size within the dimensions for which it is constructed.

Fig. 3798.



Dimension Planing-Machine.

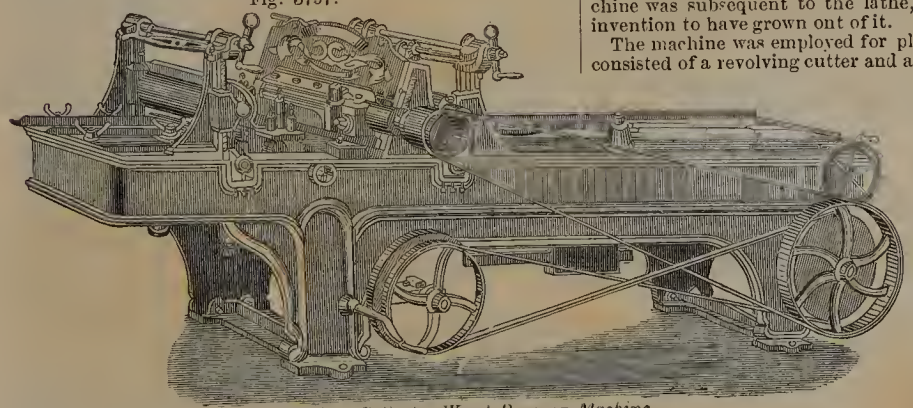
2. (*Metal-working.*) A machine in which a metallic object dogged to a traversing-table is moved against a relatively fixed cutter. In practice, the cutter is adjusted in a stock, and is usually fed automatically between strokes.

The earliest machine for planing metal was invented by Joseph Moxon, and described and illustrated at pages 208 and 215 in "Mechanick Exercises, or the Doctrine of Handy Works," published in London, 1694. The metal-planing machine was subsequent to the lathe, and would appear by this invention to have grown out of it.

The machine was employed for planing brass moldings, and consisted of a revolving cutter and an adjustable guide or table, along which the bar or brass to be planed was drawn by the operator. The machine appears to have been entirely successful for the purpose intended. This was the original *milling-machine.*

As in the case of so many important inventions, however, but little progress was made for a while, and the original invention and inventor were almost forgotten, when, nearly a century after Moxon, the necessities of the times caused the revival of the invention to be made with special ref-

Fig. 3797.



Revolving-Cylinder Wood-Planing Machine.

erence to iron. In the year 1751, the engineer of the Marly Water-Works on the Seine, France, contrived and put in execution a machine for planing out the wrought-iron pump-barrels employed in that work. (See page 454, plate 45, in Buchanan's "Practical Essays," published 1841.) This is believed to have been the first instance in which iron was reduced to a plane surface without chipping or filing.

The present metal-planing machine is an application of the slide-rest, which was invented by General Sir Samuel Bentham and described in his patent of 1793.

The planing-machine dispensed, to a great extent, with chipping and filing, and is at the bottom of all successful fitting of machinery. It is next in importance to the lathe, and has, since its invention, about 1814, been much modified and improved. Its use has effected a complete change in the manufacture of tools and machinery of every class, and has made possible the construction of many works which could hardly otherwise have been attempted.

In its invention we find credits to Clements of London, who was a workman in Bramah's shop; to Fox of Derby, and to Roberts and Rennie of Manchester. Bramah, it appears, employed, in 1811, the revolving cutter to plane iron, thus adapting to metal the form found best adapted to wood-working, and which survives in our *milling-machines*, now so much and deservedly esteemed. Clement, previous to 1820, made a planing-machine for planing the sides of looms and the triangular bars of lathes. The bed moved on rollers, and the tools cut both ways. Much of the work for Babbage's calculating-machine was planed on Clement's machines. Fox made a planing-machine, in 1821, to plane the cast and wrought iron bars used in lace-machines. It planed 10 feet 6 inches, 22 inches in width, on an object not above 12 inches high. Rennie, in 1820, it appears, had a planing-machine with a movable bed urged by an endless screw and rack and with a revolving tool.

The first machines were moved by a chain winding on a drum; rack and pinion, and eventually the screw arrangement, were substituted.

The metal-planing machine of Joseph Clement of London is illustrated and described on page 157 *et seq.*, Vol. XLIX., "Report of Society of Arts" for the year 1832. The inventor, in his communication to the society, says that he aimed to do with this machine for straight surfaces all that the lathe was made to do for round surfaces. The paring or cutting tool and the stuff to be operated upon were held respectively, as in the lathe, at fixed relative distances from each other, entirely independent of any mouth-piece, such as employed in the plane proper or carpenter's plane. This great invention included the reciprocating bed, guided and moved horizontally and automatically with a greater or less stroke. It included two cutters, capable of being directed forward and backward and at different elevations, so as to cut at both forward and backward strokes of the bed.

The cutter or cutters were fixed in a slide-head, and by suitable guides, screws, and mechanical connection with the bed, were shifted automatically at the end of every stroke, and could be fed downward at will, so as to make a deeper or shallower cut.

The cutters could be canted to one or other side to any angle whatever, so as to plane either the right or left side of the stuff. In a word, it was the planing-machine of our day. Clement was a worthy pupil of the illustrious Joseph Bramah.

Fig. 3799 is a side elevation of a self-acting planing-machine for horizontal, vertical, and angular planing.

a, bed and standards.

b, guide-screw.

c, the table, having a nut (not shown) taking into the guide-screw, by which it is moved along the bed.

d, the driving-apparatus, which, by being at the end of the bed, is out of the workman's way.

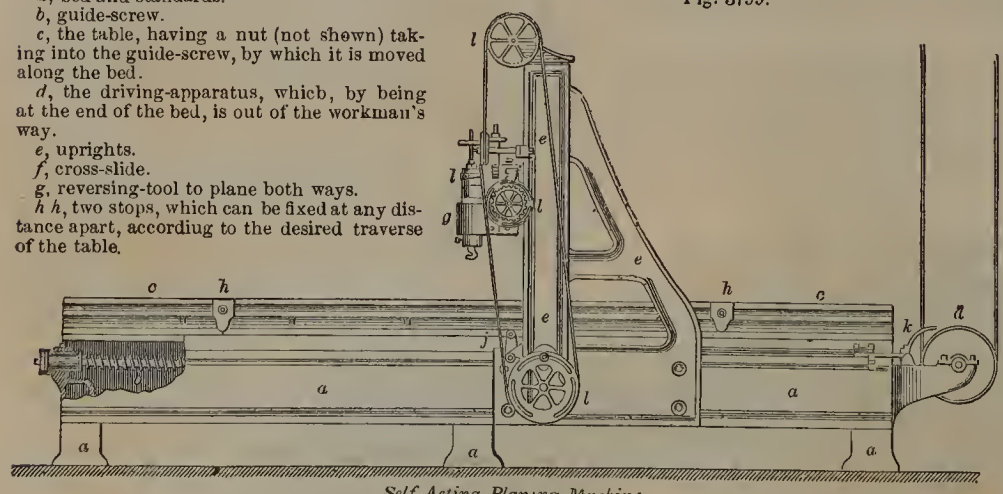
e, uprights.

f, cross-slide.

g, reversing-tool to plane both ways.

h h, two stops, which can be fixed at any distance apart, according to the desired traverse of the table.

Fig. 3799.



Self-Acting Planing-Machine.

j, lever upon which the stops *h* act.

k, rod and strap lever, by which the driving-strap is shifted from one pulley to another, and the direction in which the table *c* moves is changed.

l, band-pulleys which transmit the motion of the lever *j* to the reversing-tool at the same time as the strap is shifted, and the tool is thus made to turn at each end of the work. The band-pulleys also impart self-acting motions to the tool in the transverse, vertical, and angular directions, as required.

The reciprocation of the supplementary tool-frame at right angles to the motion of the table gives the transverse cut. The angular cut is given by the combination of the motions, transverse and longitudinal.

The same general arrangement of machine with a fixed tool, to plane only one way, and the driving-apparatus *d*, constructed to give to the table a quick return-motion, is sometimes made. The tables of machines which do not plane above two feet long are moved by a crank.

Planing-machines were farther improved by the use of two tool-boxes on the cross-slide, and by the application of slide-rests or tool-boxes fixed upon the uprights, self-acting vertically, for planing articles at right angles to the tools on the cross-slide.

The necessities of the manufacture of wrought-iron and steel ordnance, and the revolution they have caused in the construction of vessels of war, have called into requisition a great many alterations and adaptations of the present machines, as well as many entirely new ones. The planing-machine especially has been called upon to plane the edges of armor-plates to different curves, shapes, or angles. In most cases, this has been accomplished by a pattern-bar of iron or steel, placed on edge in a small chuck fixed upon the surface of the table, adjustable by set-screws, and shaped to the form to which it is required to plane the edge of the plate; as the table travels, this bar, which runs between two circular rollers attached to the under side of the cross-slide, moves the tool sideways, according to the amount of curve in the shaper or guide-bar, the tool-box being disconnected for this purpose from the screw in the cross-slide.

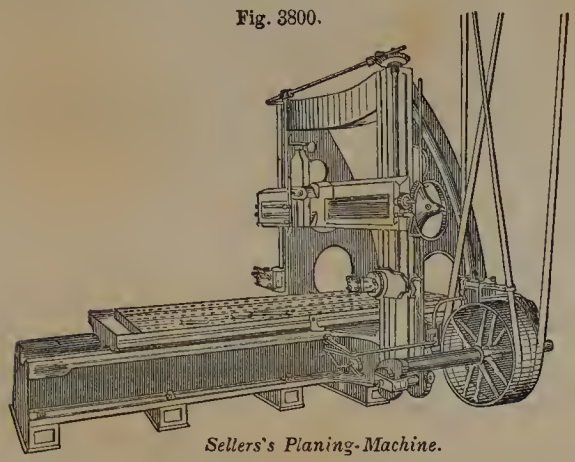
Fletcher's duplex planing-machine (English) is arranged with double beds and double tables, each table having a separate set of gearing, with starting, stopping, and feed motion. There are two tool-boxes on the cross-slide, each of which is independently self-acting, so as to work with its own table. Thus, the two tables may be used separately as two smaller machines working independently of each other, and capable of planing different lengths of work at the same time; or, when planing a large article, the two tables, gearing and motion, may be coupled, so as to form one large machine, — an arrangement rendering the machine capable of doing a variety of work. Also, one table may be fixed stationary as a bed-plate to bolt awkwardly shaped or long pieces of work upon, while they are planed by a slide-rest fixed upon the other table. When used as one machine, both sets of straps and gearing are in operation, and are reversed by the stops of one table only, so as to ensure the straps moving at the same time.

This machine is capable of planing articles 10 feet wide and 10 feet high. The racks on the under side of the tables are 3 inches pitch, with stepped teeth; the wheel working into the rack is 3 feet 9 inches diameter at the pitch-line, and is driven by a smaller pinion. By this arrangement a steadier motion is obtained; and also the pulleys and driving-gear can be placed entirely behind the face of the uprights, so as to leave the front of the machine perfectly clear, that the straps may not be in the way when putting the work on and off. The pulleys, being below the ground-line, may be driven by a horizontal underground shaft at the back of the machine, and no straps will then be visible. Machines of this description are made with beds 40 feet long, to plane work up to 14 feet in width.

Fig. 3800 is a perspective view of Sellers's self-acting planing-machine for horizontal, vertical, and angular planing of any required length, with spiral-gear driving-motion; positive geared feeds, self-acting in all directions, with tool-lifter operating at all angles, and improved belt-shifter. This machine stands parallel with the overhead driving-shaft; the bed and table are fitted to uniform gages, so that the table will work with either end toward the uprights, or on any bed of the same size machine.

Among the modifications of the planing-machine adapted for quick work, for cutting grooves and what

Fig. 3800.



Sellers's Planing-Machine.

not, may be cited the *jack*, *jim-crow*, *key-groove machine*, *milling-machine*, *planer-bar*, *shaping-machine*, *slotting-machine*.

The *jack* is a small machine, and is named from its quick, handy ways and its compact form.

The *jim-crow* is the improvement of Joseph Whitworth upon the Clement planing-machine. It has a reversing-tool to plane during both motions of the bed, and is named from its peculiar motion, being adapted to "wheel about and turn about, and do just so." The table is moved endways by a quick-threaded screw, which allows the driving motion to be placed at the end. Whitworth's English patent is No. 6850, of December 11, 1835.

The *key-grooving machine* is a modification invented by Robert Roberts of Manchester. It has a strong mortise-chisel, which is reciprocated vertically by an eccentric, while the wheel to be slotted is laid horizontally on a slide, and traversed toward the cutter until the slot has attained the depth required.

The *milling-machine* is one in which the work is dogged to a table and fed toward a revolving cutter, which has a serrated face which cuts away the metal. See MILLING-MACHINE.

The *planer-bar* is a form in which the tool is on the end of a bar, which penetrates the interior of an object, and thus is enabled to reach deep-seated places. See SHAPER-BAR. See also Fig. 3787.

The *shaping-machine* is one in which the object is chucked on an axis or mandrel, the tool traversed above the work in a line parallel with the axis of the mandrel; the latter, being slightly rotated between each stroke, constitutes the feed, and the result is a circular shape attained by straight cuts. See SHAPING-MACHINE.

The *slotting-machine* — or *paring-machine*, as it is sometimes called in England — is a substitute for the file in hollowing out objects, and thus resembles the *key-grooving* machine; but the slotting-machine has two horizontal slides at right angles to each other and a circular adjustment or turn-plate, all three used in shifting the position of the work below the vertically reciprocating cutter, and all three having devices for mechanically *feeding the cut*, as it is called, or for moving the slides between each stroke.

The *crank*-planer is a shaping-machine for metal, in which the tool-stock is reciprocated by pitman attachment to a wrist on a crank.

Plan'ish-er. A thin flat-ended tool, used by turners for smoothing brass-work.

Plan'ish-ing. An operation in which sheet-metal is condensed, smoothed, and toughened upon a smooth anvil by the blows of a smooth-faced hammer. Copper plates for engravers are thus treated to condense the metal, which is otherwise too spongy for the purpose. Burnishing has a similar effect. Planishing is also employed upon silver for table-ware and in many other instances.

Plan'ish-ing-ham'mer. A planishing-hammer has smooth, very slightly convex faces, and is used upon sheet-metal in connection with a bright, steel-faced anvil. Its action is to condense and toughen the metal, and frequently to bring it into form, as in copper kettles, pans, etc. The face of the hammer is rounded more or less, according to the radius of the concavity of the vessel under treatment.

Heavy hammers of this description have a counterbalance suspension arrangement, to relieve the exertion of raising them after each blow, or are driven by machinery.

Plan'ish-ing-roll'ers. The second pair of rollers in preparing coining-metal. They are made of case-hardened iron and polished. The metal, which was run hot through the *breaking-down* rolls, is passed cold between the *planishing-rollers*, which bring the strips to a given thickness.

Plan'ish-ing-stake. (*Coppersmithing.*) A bench stake or small anvil for holding the plate when under the action of a planishing-hammer.

Plan'i-sphere. The representation upon a plane of the circles of the zodiac.

The zodiac represented on the ceiling of the temple of Dendera was discovered in 1799 by the French savans, during their researches under Napoleon's orders. A periodical work of 1801 thus describes this work in connection with a similar work at the base of a peristyle at Esne: —

"That at Esne indicates the solstice in the sign of Virgo, and that of Dendera, which is of later date, shows the sun in Leo. The intention of the founders of these monuments was certainly to represent the present state of the heavens when these were constructed. A comparison of these two zodiacs, which may now be instituted, throws back to the most remote antiquity the construction of these temples, and proves in a striking manner the knowledge which the ancient Egyptians possessed of that astronomical phenomenon, the precession of the equinoxes." — *London Monthly Magazine.*

Modern attempts to bring the matter within the present range of written history cite the era of the Ptolemies as the date of the projected zodiac.

A smaller planisphere of the same temple, Dendera, was removed to Paris in 1821.

Visconti judged from the position of the signs that the zodiac in the ceiling of the pronaos of Dendera was constructed between A. D. 12 and A. D. 132, — a conclusion fortified by the reading of the name of Tiberius. It is not certain that the planisphere in another apartment is so modern.

Plank. 1. A board more than nine inches in width.

2. The board of a petard.

3. The frame of a printing-press on which the carriage slides.

4. The timbers which cover the *ribs* of a vessel and form the *skin*. Also those of the *deck*.

5. To unite slivers of wool in forming *roving*.

6. To harden by felting; said of hat-bodies after forming. They are *planked* or *hardened* to give them solidity, thickness, and strength.

Plank-hook. A pole with an iron hook at the end, with which quarrymen, miners, and others shift their *runs* or wheeling-planks, as occasion requires.

Plank'ing. 1. (*Shipbuilding.*) The *skin* or wooden covering of plank on the exterior and interior surfaces of the ribs and on the beams.

A line of planking is a *strake*, and is named from its position; as, *garboard*-strake, *bilge*-strake, *side*-strake, *shear*-strake, etc.

When the seam between two planks is straight, it is said to be *fair-edged*; when it is sloped, it is called *anchor-stock* or *top and butt*, according to the character of the sloping.

Wales are strakes of thicker plank. The term is used in shipbuilding, and also in *piling*. See PILE, page 1700.

2. (*Spinning.*) The splicing together of slivers of long-stapled wool. See BREAKING-MACHINE.

3. (*Steam.*) The *lagging* or *clothing* of a steam-cylinder. *Cleading.*

Plank'ing-clamp. (*Shipwrighting.*) An implement for bending a strake against the ribs of a vessel and holding it till secured by bolts or treenails.

In Fig. 3801 the chain-hooks catch against the ribs and afford a hold for the planking-clamp to strain against.

Fig. 3801.

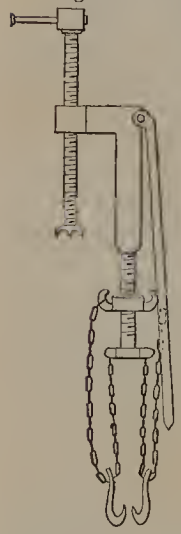
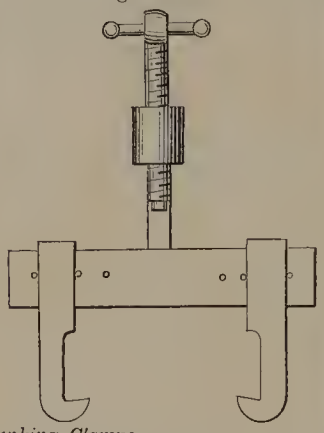


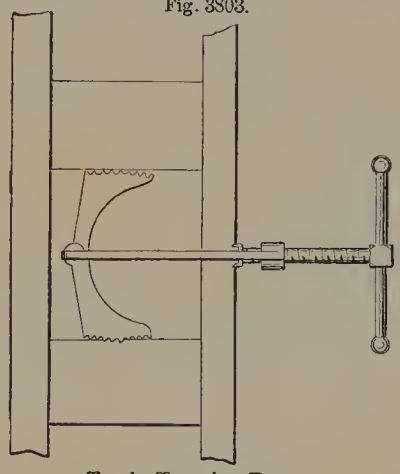
Fig. 3802.



Planking-Clamps.

Fig. 3802 consists of a strain-bar with a knee, in which works a screw for pressing up the plank. Two hooks pass in the opposite direction from the strain-bar, and are adjustable thereon and take hold of the timber and hold so that the screw will force the plank up to its place.

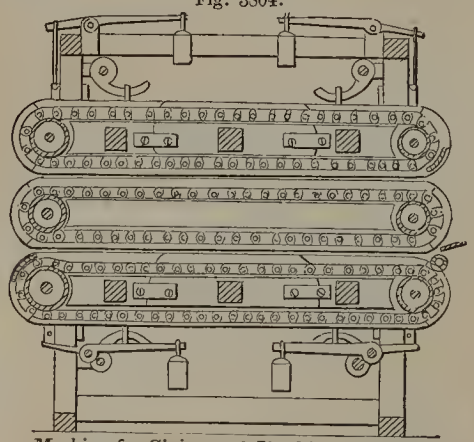
Fig. 3803.



Toggle Clamping-Frame.

The clamping-frame (Fig. 3803) has toggle-levers whose serrated segmental ends engage the ribs or joists, the screw acting on the plank.

Fig. 3804.



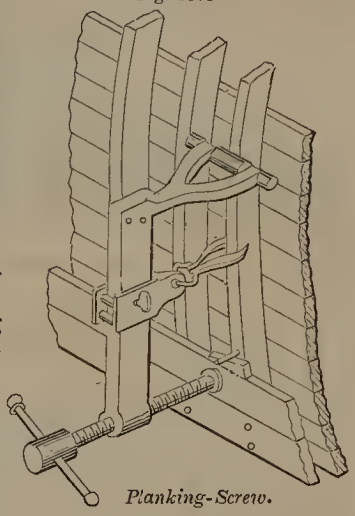
Machine for Sizing and Planking Hat-Bodies.

Plank'ing-ma-chine'. A machine in which hat-bodies, after being formed, are rubbed, pressed, and steamed to give them strength and body.

In the example, the intermediate belt of lags is the working-apron; the upper and under aprons may have a different velocity or merely act as beds. A shell at the exit of the upper apron aids in discharging the work. In the arrangement for returning the work to continue the operation, a roller and board keep the felt clear of the lower apron till it is caught by the apron above. Steam is introduced between the aprons, the upper and under ones of which are counterweighted and vertically adjustable. See HARDENING.

Plank'ing-screw. An implement for straining planks against the ribs of vessels.

Fig. 3805.



Planking-Screw.

In the example, the fulcrum-point of the lever is dogged to the rib, and while one end is propped against the rib the other has a clamping-screw which brings in the plank to the shape of the frame. The lever slips in the clevis and the prop upon the rib to adjust the screw in the required position.

Plank-re-vet'ment. (*Fortification.*) Board lining of an embrasure or covering of a rampart.

Plank-road. A road of transverse planking or puncheons laid on longitudinal sleepers or string-pieces. A *plank-way.*

One mode of forming such a road is as follows: Two ditches are dug 16 feet apart, the earth being thrown on to the included strip. One half of the track is left as an earthen surface sloping toward the ditch on that side, the other is planked. Imbedded in the ground are laid longitudinal sleepers, 4½ feet apart. Each sleeper is from 12 to 20 feet long, 12 inches broad, and 4 inches deep. The sleepers are supported at the joints by scantling beneath. The planks are 8 feet long and 3 inches thick.

Plank-sheer. (*Shipbuilding.*) A plank resting on the heads of the top timbers of the frames or ribs. The *gunwale.*

Pla'no-con'cave Lens. A lens, one of whose sides is a plane and the other is curved inwardly. See LENS.

Pla'no-con'vex Lens. A lens one of whose sides is a plane and the other is curved outwardly.

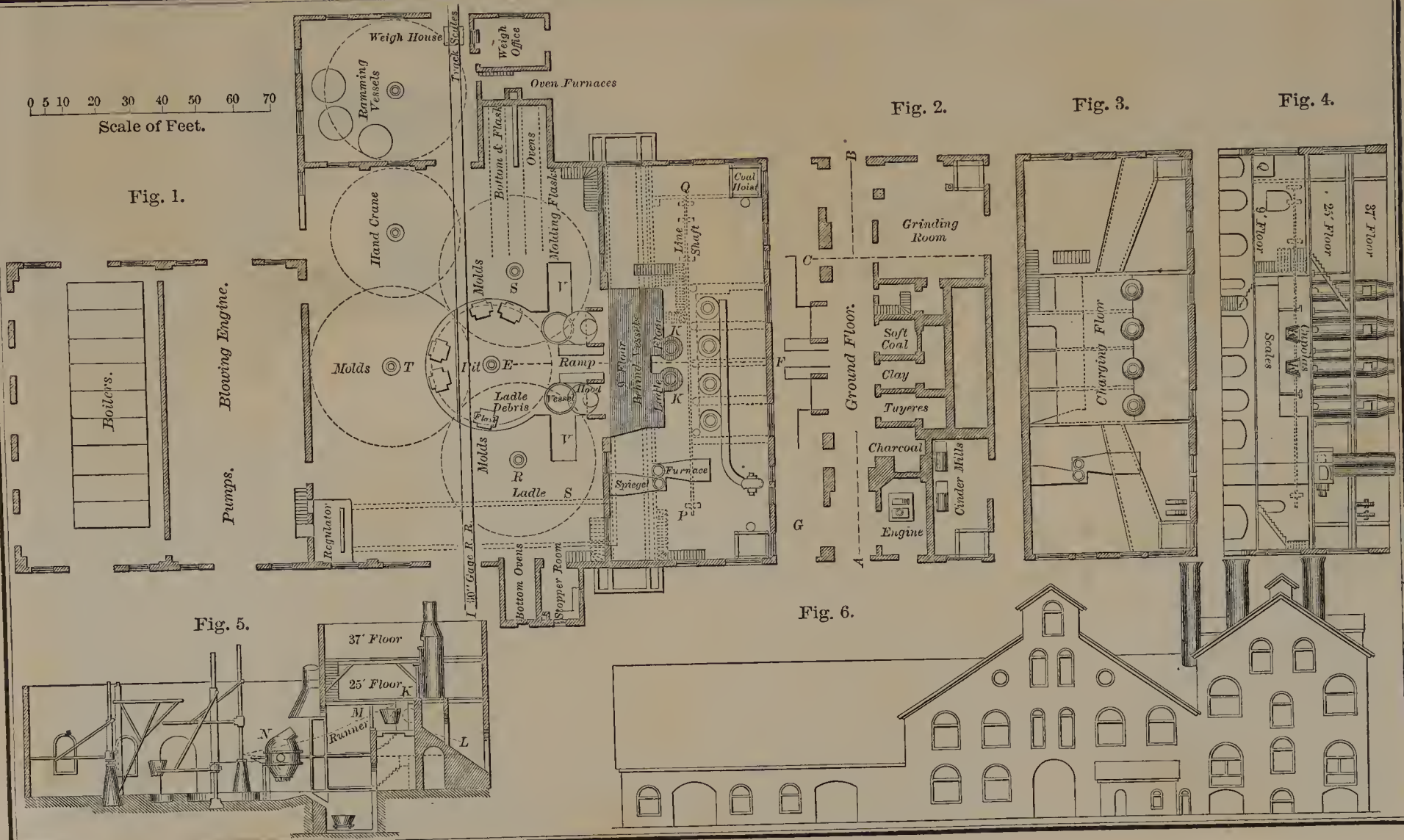
The *doublet* and *triplet* are combinations of plano-convex lenses. See LENS; DOUBLET; TRIPLET.

Pla-nom'e-ter. A trial or plane surface on which articles are tested for straightness and level. It affords a standard gage for plane surfaces. (See PLANE.) An approved form consists of a cast-iron plate stiffened on the back by transverse and longitudinal ribs. The latter, two in number, converge to a point at one end, so that in use it always rests on three points of support. It is provided with a handle at each end. See PLANE-SURFACE.

Plant. A set of tools, machinery, apparatus, and fixtures as used in a particular business, *e. g.* the tools, benches, vises, lathes, planers, etc., of a machinist; the forge (including bellows), anvil, hammers, tongs, etc., of a blacksmith. That which is necessary to the conduct of the mechanical business, whatever it may be. The more complete the assortment of tools, the better their quality; and the more numerous they are, the more valuable is the *plant.*

The rolling stock of a railway.

The vats, tubs, stills, coolers, etc., of a brewery or distillery.



See page 1734.

PLATE XLII.

AMERICAN FIVE-TON BESSEMER PLANT.

(*Product 80 tons per 24 hours.*)

According to a report recently published in Germany, the working plant of Krupp's steel works at Essen was, during the last year, 514 melting, annealing, and cementing furnaces, 169 forges, 249 welding, puddling, and reheating furnaces, 245 coke-ovens, 120 miscellaneous ovens or kilns, 256 steam-engines (collectively of 8,377 horse-power), 340 lathes, 119 planing-machines, 65 shaping-machines, 144 boring-machines, 120 unclassed machines, and 90 grindstones. There were also 56 steam-hammers, one of which weighs 30 tons. The number of workmen employed were 7,100, and 70,000 tons of steel were turned out. The Bessemer convertors, of which there are several at work, are not enumerated in this list.

Plate XLII. illustrates the Bessemer works of the North Chicago Rolling-Mill Company, from which those of other large American works do not essentially differ.

Fig. 1 is a ground plan of the converting-engine and boiler-houses, and of the 25-foot floor of the cupola building.

Fig. 2 is a ground plan and Fig. 3 a plan of the 37-foot or cupola charging-floor.

Fig. 4 is a section at *A B*, Fig. 2, showing the cupolas and their ladles in elevation.

Fig. 5 is a section at *E F*, Fig. 1, showing a side elevation of the cranes, convertors, cupolas, etc.

Fig. 6 is an end elevation of the buildings.

The ground-floor of the works, contrary to the English practice, is all on the same level, is accessible from all sides, and the engine and boiler houses are at the side of the converting building, leaving the ends open for the through passages *A B I J*.

The hoist for coal, etc., and that for iron are at opposite ends of the cupola building,—an arrangement which allows more room in the yard than if they were placed side by side.

A hydraulic cylinder, whose stroke is equal to one half the distance traversed by the hoist, is most convenient and durable.

The pig-iron and coal for the charges are carried on light four-wheeled iron wagons, easily managed by one man. These possess the advantage over those of larger size, of being less liable to interfere with each other upon the charging-ground, and also afford greater facilities for the intimate intermixture of the different qualities of pig-metal, of which six or more kinds are thoroughly mixed in each wagon before charging.

In this country, cupolas are used instead of reverberatory furnaces, and this practice is being introduced abroad. The cupola is cheaper to construct and maintain, affords greater heat, melting the metal more rapidly, and melts 5 to 6 pounds of metal to the pound of coal. It also occupies much less room and requires a less costly building than the reverberatory furnace.

In order to adapt the ordinary foundry cupola to the Bessemer process it was found necessary to increase the depth from the tuyeres to the tap from one foot to three or four feet, to double the sectional area of the tuyeres, and to reduce the projection of the boshes.

The dimensions of the cupolas are about as follows: hight, 14 feet; interior diameter of elliptical cupola, 6′ 5″ by 3′ 5″; the aggregate sectional area of the tuyeres, six in number, is 200 square inches. Circular cupolas having the same sectional area are sometimes employed.

The charge consists, first, of 5,400 pounds of coal, over which are placed from 3 to 3¾ tons of pig-iron; this is succeeded by 1,400 pounds of coal, over which is charged the same amount of metal. These alternate charges of coal and metal are continued until the cupola is filled, a small quantity of limestone being added as a flux. The cupola is kept filled to the charging-door for from 8 to 10 hours. It will hold 5 tons during the first few charges; but as the hearth becomes filled with slag, the capacity is decreased, and more frequent tapping is required. They are capable of melting 100 tons of iron in 9 hours. The molten iron is tapped from the cupola into ladles *K*, having a capacity of 12 tons each. The objects of interposing ladles between the cupolas and convertors, instead of tapping directly into the latter, are, (1.) that the gray iron charges may be accurately weighed, so that the amount of spiegeleisen to be added may be definitely ascertained; (2.) the convenience of holding the metal until the vessels are ready to receive it. Pressure-blowers have been usually employed for the cupolas, but of late the Sturtevant fan-blower has been successfully introduced at the Troy works.

The cupola dump *L*, Fig 5, is situated conveniently to the cinder-mill, Fig. 2, where the cinders are ground, so that the *shot-iron* may be saved and remelted.

The cupola charging-floor is over the ladles, thus permitting the width of the building to be reduced. The molten metal is conveyed from the cupolas to the convertors by means of the ladles *K* and runners *M*. These deposit it in a trough having branches by which it is conducted to either convertor. The spiegeleisen furnaces are shown in plan Fig. 1, and in cross section Fig. 4.

Reverberatory furnaces are preferred for melting spiegeleisen, as the charges may be kept hot longer. Cupolas are, however, used in some works. The engine which drives the blower is placed beneath the charging-floor of the building, to economize space. This engine also drives the cinder-mills. At the opposite end of the converting building a space is left for grinding and mixing the refractory material for lining vessels, etc.

In the converting department of all American works the vessels are placed side by side and raised above the general level. A platform extends around the convertors, by means of which all parts of the vessels are easily accessible. A passage *Q* on the same level affords access to the coal-hoist. This arrangement also allows greater swing to the cranes, the side ingot-cranes *R* and *S* commanding the vessels, the pit, and all the floor room over which they swing. The central ingot-crane *T* commands the pit and a large floor space, and all the cranes swing over the railroad *I J*. The ingots are removed by cars as fast as produced, and taken to the weighing-house at the end *J* of the road.

The cupola building has bins for holding the materials, as coal, etc., required for current use. Where, as in England, everything in the melting department is on different levels, the buildings are necessarily large, the distance between the bins and the places where their contents are to be used great, and the operations interfere with each other, whereas in a high building with several floors the operations are simplified and the materials more conveniently stored. Thorough ventilation is secured by lantern roofs and windows on every side.

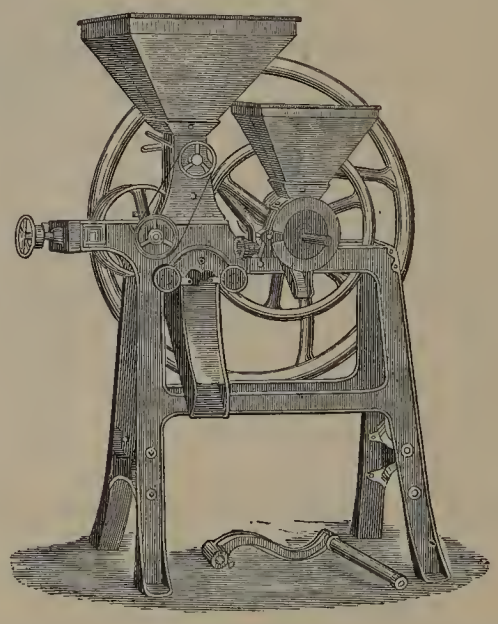
The hight of the cupola building, allowing free ventilation on all sides, is an important feature. The gangway *A B*, Fig. 2, is convenient for ventilation, also for reaching all sides of the vessels, as well as for transportation. Underneath this, in the newer works, is an underground passage (Fig. 5) which communicates with the cellar under the grinding-mill and the coal-hoist. This serves for removing waste material. The water and blast pipes leading from the regulator are secured to the walls of this passage; an indispensable precaution in a cold climate.

Until recently, only eight heats per day could be made with the five-ton convertors, owing to the difficulty of replacing the bottoms of the converting vessels when the tuyeres were worn too short. This difficulty has been overcome by Mr. Alexander L. Holley, the consulting engineer of the principal Bessemer steel works of the United States. Since Mr. Holley's improvements but two or three hours time is required to replace a bottom. This has doubled the production, from 16 to 25 five-ton heats now being made in a day of 24 hours. The quantity of metal usually charged into the convertor at each heat is from 12,000 to 12,500 pounds, to which from 5 to 8 per cent of spiegeleisen is added at the close of the operation.

The steel is cast into ingots which are afterward rolled into blooms. In a few American works, however, they are hammered into blooms. See BESSEMER PROCESS; CONVERTOR.

Plan-ta′tion-mill. A crushing-mill for oats, linseed, etc., adapted to plantation use. It has two hoppers *a b* with separate delivery-spouts, so that two different kinds of seeds may be ground at once,

Fig. 3806.



Plantation-Mill.

or seed of the same kind may be ground to two different degrees of fineness. The mill may be driven by horse or hand power.

Plant′er. See CORN-PLANTER; COTTON-SEED PLANTER; POTATO-PLANTER, etc. See list under AGRICULTURAL IMPLEMENTS.

The following table is useful for calculating the number of seeds, plants, shrubs, trees, or what not, to an acre of ground at given distances apart.

Hills in an Area of an Acre.

Feet Apart.	No.	Feet Apart.	No.	Feet Apart.	No.	Feet Apart.	No.
1	43,560	5	1,742	9	538	16	171
1½	19,360	5½	1,440	9½	482	17	151
2	10,890	6	1,210	10	435	18	135
2½	6,969	6½	1,031	10½	391	20	108
3	4,840	7	889	12	302	25	69
3½	3,556	7½	775	13	258	30	48
4	2,722	8	680	14	223	35	35
4½	2,151	8½	692	15	193	40	27

Plaq'uage-style. A mode of calico-printing. See PADDING.

Plash. To interweave branches, as for gabions, dikes, weirs, hurdles, etc.

Plasm. A mold or matrix.

Plas'ter. 1. (*Plastering.*) *a.* A composition of lime, sand, and water, with or without hair as a bond, and used to cover walls and ceilings.

b. Calcined gypsum or sulphate of lime, used, when mixed with water, for finishing walls, for molds, ornaments, casts, luting, cement, etc.

It is also the basis for stucco and scagliola or artificial marble.

The hydrated sulphate of lime is calcined at a heat of about 300° Fah., and parting with 20 per cent of water falls into a white powder. While it decrepitates it does not decompose, like limestone, but is greedily absorbent of water, and by combination therewith becomes again solid.

Calcined with alum it forms *Keene's cement*, which solidifies more slowly than the common plaster of Paris, but is harder when set. See CEMENT.

Reburnt with borax and other substances, it produces other and fine cements. See CEMENT.

The mortars used for *inside plastering* are termed *coarse*, *fine*, *gage* or *hard finish*, and *stucco*.

Exterior plaster or stucco: 1 volume of cement powder to 2 volumes of dry sand.

In India, to the water for mixing the plaster is added 1 pound of sugar or molasses to 8 imperial gallons of water, for the first coat; and for the second or finishing, 1 pound of sugar to 2 gallons water.

Turkish plaster or hydraulic cement: 100 pounds fresh lime reduced to powder, 10 quarts linseed-oil, and 1 to 2 ounces cotton. Manipulate the lime, gradually mixing the oil and cotton, in a wooden vessel, until the mixture becomes of the consistency of bread-dough.

Dry, and when required for use mix with linseed-oil to the consistency of paste, and then lay on in coats. Water-pipes of clay or metal, joined or coated with it, resist the effect of humidity for very long periods.

The names of plaster coatings are as follows: —

First coat of two-coat plastering: *laying*, when executed on lath; *rendering*, when executed on brick.

First coat of three-coat plastering: *pricking-up*, when executed on lath; *roughing-in*, when executed on brick.

Second coat: *set*, in two-coat plastering; *floating*, in three-coat plastering.

Third or *finishing* coat: *stucco*, when for painting; *setting*, when for papering.

Or, as follows: —

Lath, laid, and set: lath with two coats of plaster.

Lath, laid, set, and colored: the addition of coloring to the former.

Lath, pricked-up, floated, and set: three-coat work.

Lath, floated, and set fair: same as the last.

Roughed-in, floated, and set: three-coat work on brick walls.

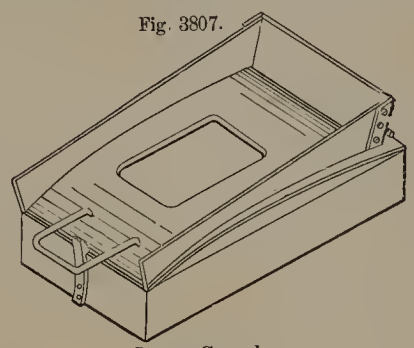
The Greeks used a very durable mortar for stucco and plastering. Their walls and floors are yet hard and white, and retain their polish in instances where they have not been mutilated.

The Romans plastered their cisterns and reservoirs with a mixture of pure lime and pounded brick, which hardened into a mortar resembling breccia, which has nodules of red matter in a white matrix. This was beaten to render it plastic, and it was then *floated* on to the walls by sandstone trowels, which were rubbed over the surface to smooth it. Over this was laid a coat of fine plaster covered by one of red-lead and oil.

2. (*Medicinal.*) Plasters are spread by placing the material upon the wash-leather or paper, on which is laid a mask which determines the margin when the material is flattened by the hot spatula. One form of the device has a pair of masks which move over each other so as to expose an opening of any required size and proportions.

Fig. 3807 has a shield hinged to a block which has a concave upper surface. The leather is clamped between the shield and bed, and is exposed at the opening in the former.

Fig. 3807.



Plaster-Spreader.

Perkins's patent, January 15, 1830, has a pair of rollers, between which the leather is run, flattening down the plaster upon it.

Blisters were made by Hippocrates, 400 B. C. Cantharides are commonly found in Spain, and their use is ascribed to Aretæus of Cappadocia, 50 B. C.

Sticking-plaster is made as follows: Two solutions are first made: one, an ounce of isinglass in eight ounces of hot water; and the other, of two drachms of gum benzoin in two ounces of rectified spirits. These solutions are to be strained and mixed. Several coats of this mixture, kept fluid by a gentle heat, are then to be applied with a camel's-hair brush to a piece of silk stretched on a frame, each coat being allowed to dry before the next is applied. A layer of a solution composed of one ounce of Chian turpentine in two ounces of tincture of benzoin is then to be applied to the other side of the silk and allowed to dry.

Plas'ter-cast. A copy of an object obtained by pouring plaster of Paris (sulphate of lime calcined and pulverized) mixed with water into a mold which forms a copy of the object in reverse.

While the art of modeling in clay was attributed by the ancients to Dibutades the Corinthian, about 985 B. C., that of taking plaster casts is attributed by Theophrastus and Pliny (A. D. 70) to Lysistratus of Sicyon, a brother of the celebrated sculptor Lysippus. He first took plaster casts, and from these obtained a second cast in wax. The plastic nature of the latter enabled him to rectify imperfections and form an enduring, life-like copy. The names of Rhœcus and Theodorus of Samos are also noted in this connection.

After being neglected for centuries, the art was revived by Verocchio (1422–88) and by others; the immediate incentive being to obtain copies of the specimens of ancient art which were being disinterred and discovered. The sovereigns of France also took this means to add to the artistic interest and beauty of their capitals and art museums.

In making plaster casts the gypsum is mixed with water, the proportion of the latter depending on the purpose to which it is intended to be applied. The more fluid the mixture is, the more easily and perfectly will it enter the finest lines of the mold; but such casts, when dry, are more porous and therefore more tender than those in which a smaller quantity of water has been used. Much also depends on properly mixing the ingredients; the water must never be poured on the powder, but the powder must be shaken into the water, and the best way of doing this is to take up the powder between the fingers and thumb, and then allow it to drop gradually into the water, taking care that it does not run into lumps, and that every particle becomes thoroughly soaked. Proceed in this way till the powder comes to the level of the water, and then stop if a thin plaster is wanted; but, if a stronger one is required, keep adding powder till it stands about a tenth of an inch above the water. When the whole of the gypsum has been put in, allow the ingredients to remain undisturbed for a few seconds, and then stir up the mixture cautiously and gently with a spatula, and as soon as it begins sensibly to thicken pour it into the mold. The great error that amateurs fall into in this part of the process arises from want of patience; they put the powder into the water too hastily, generally employing too much of it, and keep incessantly stirring it till it thickens; the consequence of which is, that it contains air-bubbles, is hard in some places and soft in others, and is not capable of being perfectly united to a succeeding layer of plaster. Good plaster, when mixed with the proper quantity of water, should be of the consistence of cream, and will set or become solid in about ten

minutes, but cannot safely be removed from the mold till about half an hour afterward.

If a mold is to be made of a simple object, it is evident that it must be formed in at least two parts, that we may be able to extract the cast, or allow the mold to *deliver*, as it is called; and in the case of any regular geometrical figure two parts only are necessary. The same may be said of any figure whatever which has no recesses or projections whose sides do not overlay any portion of the mold in the direction in which it is necessary to withdraw the latter. Should any of them do so, it will be necessary to construct the mold of a greater number of parts, so that each separate part may be removed in the direction of the wider part of the opening formed by the object and the projection. A great part of the art of the molder consists in forming these *safe* molds, as they are called, in as few pieces as possible. Nevertheless, in intricate pieces of statuary it is said as many as 700 or more separate pieces are required.

Deeble's mode of obtaining casts of leaves is to lay the leaf face upward on a bed of fine-grained, moist sand, and cover it by means of a camel's-hair brush with a mixture of wax and Burgundy pitch made fluid by heat. The leaf, being then removed from the sand and dipped in cold water, is readily withdrawn from the wax mold, which is then placed in sand, as the leaf was, and covered with a thin plaster laid on with a brush and forced into all the interstices of the mold; more plaster is then poured on, which, in setting, evolves sufficient heat to render the wax pliable and allow it to be removed from the cast.

Mr. Fox's method of forming an elastic mold in two pieces capable of delivering undercut surfaces is, after oiling the body to be molded, to cover it completely with a thick mixture of warm melted glue with a little treacle. The glue, when cold, is cut into two parts, and may be removed without difficulty from the object. They are then oiled internally and bound together, and the cavity being filled in the usual way with plaster, affords a perfect cast.

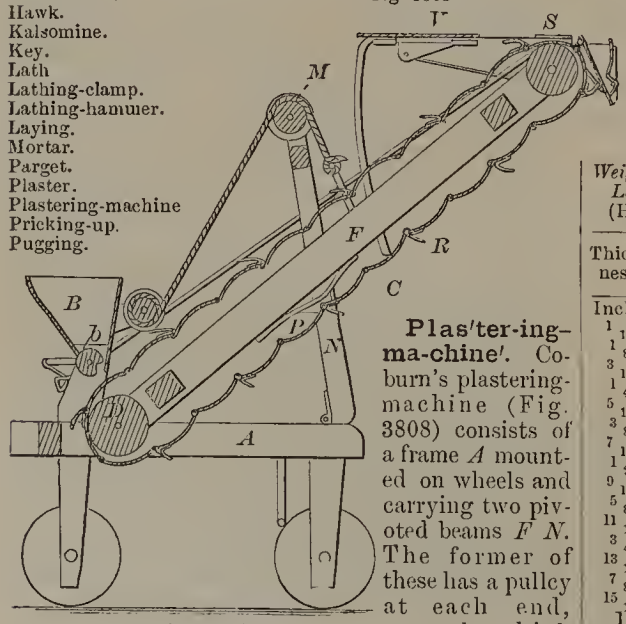
Luster may be imparted to plaster casts by dipping them repeatedly in a hot, saturated solution of alum. The surface of the cast is thereby hardened, and a certain amount of translucency obtained.

Another mode is to dry it, then coat with melted white wax and warm at a fire to effect the absorption of the wax.

Plas'ter-ers' Tools and Work. See —

Angle-bead.
Angle-float.
Angle-staff.
Bastard-stucco.
Batten.
Boss.
Coarse stuff.
Coat.
Darby.
Dots.
Dubbing out.
Fine stuff.
Finishing-coat.
First-coat.
Float.
Floating.
Gage stuff.
Grounds.
Hand-finish.
Hawk.
Kalsomine.
Key.
Lath
Lathing-clamp.
Lathing-hammer.
Laying.
Mortar.
Parget.
Plaster.
Plastering-machine
Pricking-up.
Pugging.
Rendering.
Rough-cast.
Roughing-in.
Rule.
Scagliola.
Screed.
Screen.
Second coat.
Set.
Setting.
Shave-hook.
Staff-angle.
Stucco.
Three coat work.
Trowel.
Troweled.
Two-coat work.

Fig 3808



Plastering-Machine.

Plas'ter-ing-ma-chine'. Coburn's plastering-machine (Fig. 3808) consists of a frame *A* mounted on wheels and carrying two pivoted beams *F N*. The former of these has a pulley at each end, around which passes an endless band carrying a series of trowels *R*. Mortar is placed in the hopper *B*, and by turning a crank the endless band is set in motion, and at the same time the grooved roller *b* is rotated, supplying each trowel with mortar as it passes under the hopper. The trowels are successively carried forward, and their contents successively applied to the surface (a ceiling in the illustration) to be plastered. After giving its stroke each trowel is automatically tilted, and returns to receive a fresh supply from the hopper. *V* is a gage for smoothing and regulating the thickness of plaster, the surplus of which is carried off by a slide. The machine is pushed forward as the work advances, the beam *F* being raised or lowered to suit the work by a rope passing over a pulley *M* on the beam *N*.

Plas'ter-mill. One for grinding gypsum or lime for mortar. See MORTAR-MILL.

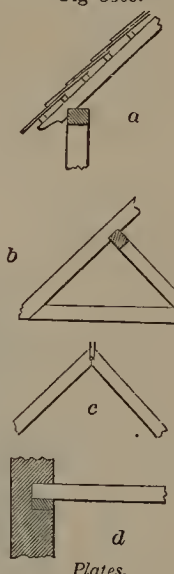
Plas'ter-spat'u-la. A piece of steel about 3 inches long by 1 wide and ¾ thick, in a long handle. By its means plaster is *spread* on muslin or sheepskin. It is heated and used something like a flattening iron.

Plat. (*Nautical.*) A braid of *foxes*, used as in service for a cable in the hawse. A *fox* is a short rope made by twisting a few rope-yarns together. See PLAIT.

Plat-band. (*Architecture.*) *a.* A plain flat ashlar or a molding on a capital from which an arch springs. An *impost.*

b. A flat fascia, band, or string, whose projection is less than its breadth; the lintel of a door or window is sometimes so named.

Fig. 3809.



Plates.

Plate. 1. (*Carpentry.*) *a.* A beam on a wall or elsewhere to support other portions of a structure. A *capping-piece.*

a, *rafter*-plate.
b, *purlin*-plate.
c, *crown*-plate.
d, *wall*-plate.

2. (*Nautical.*) *a.* An iron band or bar: as the *back-stay* plate connecting the dead-eye of the back-stay to the after channel; *futtock*-plates; *channel*-plates, etc.

b. A sheet of metal forming a portion of a strake on a ship's side.

3. A thick sheet of metal for forming a portion of a boiler or similarly constructed object.

Weight of a Square Foot of Cast and Wrought Iron, Copper, Lead, Brass, and Zinc, from 1/16 to 1 Inch in Thickness. (HASWELL.)

Thickness.	Cast-Iron.	Wrought-Iron.	Copper.	Lead.	Brass.	Zinc.
Inch.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1/16	2.346	2.517	2.89	3.691	2.675	2.34
1/8	4 693	5.035	5.781	7.382	5.35	4.68
3/16	7.039	7.552	8 672	11.074	8 025	7.02
1/4	9 386	10 07	11.562	14.765	10.7	9 36
5/16	11 733	12 588	14 453	18.456	13.375	11.7
3/8	14.079	15 106	17.344	22.148	16 05	14.04
7/16	16.426	17.623	20.234	25.839	18.725	16.34
1/2	18.773	20.141	23.125	29.53	21.4	18.72
9/16	21.119	22.659	26.016	33.222	24.075	
5/8	23.466	25.176	28.906	36.913	26 75	
11/16	25.812	27.694	31 797	40.604	29.425	
3/4	28.159	30.211	34.688	44 296	32.1	
13/16	30 505	32.729	37.578	47.987		
7/8	32.852	35.247	40.469	51.678		
15/16	35 199	37.764	43.359	55.37		
1	37.545	40.282	46.25	59.061		

NOTE. The wrought-iron is that of hard-rolled Pennsylvania plates, and the copper that of hard-rolled plates from the works of Messrs. Phelps, Dodge, & Co., Conn.

4. (*Steam-engine.*) To *plate* a *port* is to close it by the *land* or unperforated portion of the plate of a slide-valve.

5. (*Horology.*) One of the parallel sheets of metal in a watch or clock into which the principal wheels are pivoted.

6. (*Dentistry.*) The portion which fits to the mouth and holds the teeth of a denture. It is of gold, silver, aluminum, or vulcanite.

7. (*Metallurgy.*) A flat metallic piece in a furnace, usually a part of the bed or bosh.

8. (*Hat-making.*) A *plate-hat* is one of which only the outer layer is fur.

9. (*Printing.*) A page of type, stereotype, or electrotype, for printing.

10. (*Engraving.*) *a.* The metallic surface in which an engraving is cut. Hence the names *plate-engraving, copperplate,* etc.

b. An impression from such an engraved plate.

11. A piece of metal to be attached to an object; as a *name*-plate to a trunk, a *door*-plate, a *coffin*-plate, a *finger*-plate, to keep the stain of fingers from a door, etc.

12. A piece of service of silver, gold, or their imitations.

The Roman *patera* or *patella* (a plate, dish, or saucer) was of metal or earthenware, often highly ornamented, and sometimes with a handle. In the latter condition it looked like and was occasionally used as our griddle.

The *patina* seems to have been deeper, like a bowl, and sometimes had a cover. A large bowl was *crater;* the ladle, *cyathus;* a drinking cup, *poculum.* See Smith's "Dictionary of Greek and Roman Antiquities," *Patera; Patina.*

13. A small, shallow vessel for table service; one at a time for each guest, in contradistinction to the dish which holds the viand from which a guest is helped.

Pepys complains that at the Lord Mayor's dinner, London, 1663, the major part of the guests had "no napkins nor change of trenchers, and drank out of earthen pitchers" and ate from "wooden dishes."

Pewter and wood were the ordinary ware for many centuries. Afterward, common earthenware. Imported ware from China gave the fillip to some persons of ingenuity and taste, the principal one of whom was Wedgewood. See POTTERY; PORCELAIN.

Plate-bend'ing Ma-chine'. A machine for bending plates of metal to any required curve for boilers, water-wheel buckets, etc. Those for forming regular curves comprise three rolls, two of which are driven by gearing, and the third, generally the upper one, runs free.

In the illustration, *a b* are the driven rolls, rotated in either direction by the gears *c d*. The bearings of the free roll *e* are raised or lowered by turning the hand-wheel *f*, which, by means of the gear-wheels *g*, rotates the shaft *h*, having a worm at each end gearing with worm-wheels *i*, which turn screws supporting the bearings of the roll *e*. By varying the distance between the upper and lower rolls, a greater or less curvature is given to the plate, the curvature being greater in proportion to their nearness together.

Fig. 3810.

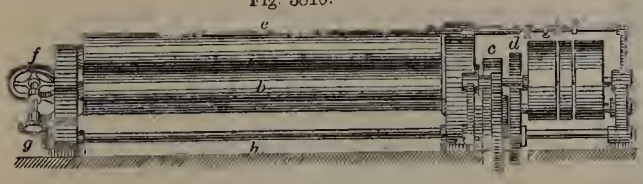
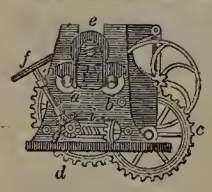


Plate-Bending Machine.



In some machines of this kind the upper roller is provided with separate adjustments at each end, so that, by raising one end more than the other, plates may be bent to a conical shape, or by altering the relative hight of its bearings, their surfaces may be made of an elliptic, parabolic, or other non-circular curve.

For bending the thick and irregularly curved plates required for armor-plating a powerful form of press is employed. The upper and lower beds have each a series of parallel longitudinal bars, adjustable by screws, so that a special curve may be given to each plate. The bars of the two beds are adjusted so as to correspond, and the plate, flat, as it comes from the forge or rolling-mill, is placed between them, and the movable bed, usually the lower, is caused to approach the other by screw or hydraulic pressure. See ARMOR-PLATING; ROLLING-MILL.

Plate-brass. Rolled brass. *Latten.*

Plate-en-grav'ing. A mode of engraving as distinct from the *relief* engraving on wood. The lines are cut into the plate, are filled with ink, and the surface is wiped clean and polished; soft paper is laid on the plate, and both are run through a roller-press. See COPPERPLATE-ENGRAVING, pages 618, 619.

Engraved plates are multiplied by the electro-plating process.

1. A *reverse* of the plate is obtained by deposition of copper in the bath. This mold is in cameo, and from this as many intaglio copies of the original may be obtained as may be desired.

2. An impression of the plate is taken on thin paper with an ink of gum-dammar, oxide of iron, and essence of turpentine. This is transferred to a copper plate; the paper is removed by washing, and the cameo thus obtained is placed in the bath for the deposition of an intaglio for the printer.

Plate-glass. Plates of glass covered with tinfoil, for mirrors, were made in Venice during the sixteenth century, but the invention of casting glass to form plates is due to Abraham Thevart. In the year 1688, plates 84 × 50 inches were cast by his process at St. Gobin, in Picardy.

A plate-glass manufactory on a small scale was established at Lambeth in 1673, but the manufacture does not appear to have flourished in England until it was undertaken by the British Plate-Glass Company, chartered by act of Parliament in 1773. Their works at Ravenshead, Lancashire, are still in operation.

The ingredients and their proportions, employed in making plate-glass, are kept secret as far as possible by the manufacturers. The following is given as one of the formulas: Silica, 78 parts; potash, 2; soda, 13; lime, 5; alumina, 2.

The materials, in a comminuted form, are fused in crucibles or pots exposed to an intense heat in a furnace; the complete fusion requires about 20 hours. From the pots it is ladled into a cistern, the *cuvette*, which is also placed in a hot furnace, where it remains until the glass is fined and in proper condition to flow readily and equably. When this occurs, the cuvette is lifted out of the furnace by means of tongs and hoisted on to a carriage by which it is moved to the casting-table. It is now skimmed to remove impurities from its surface, and hoisted by a crane immediately over the casting-table. See CUVETTE, Fig. 1579; CASTING-TABLE, Fig. 1181.

The casting-table is surrounded by side and end ledges, corresponding in depth to the thickness of the plate to be made, to prevent the escape of the liquefied glass which is poured upon it by tilting the cuvette. During the pouring a washer is drawn immediately in front of the glass to remove any dirt from the casting-slab, and when this has been covered to the requisite depth a heavy copper roller is passed over the surface of the glass, causing it to exhibit a beautifully iridescent play of colors: this roller flattens its upper surface, and causes any excess of the metal to be thrown off at the end of the table, where it is received in a trough of water.

A thick flange of the glass is turned up at the end of the plate, to which, when somewhat hardened, a rake-shaped iron is applied, by which it is forced into the annealing-oven or upon a carriage by which it is conveyed to the oven. As the plate is yet plastic, its under side takes an impression from the bricks of the oven, while its upper surface, though smooth, is un-

even; it consequently requires to be ground and polished. After remaining in the oven about five days and being allowed to cool gradually, it is carefully examined to see if it will admit of being finished as a single plate, or whether it has flaws or knots which necessitate its being cut into smaller pieces. If the latter be the case, the defective portions are cut out and the remainder serves for plates of less size.

In either case the plates are imbedded in plaster of Paris upon stone tables about 8 × 15 feet in width and length; these are arranged in pairs, at about 10 feet distance apart.

Other plates of glass are cemented to the under surfaces of two swing-tables or runners, which, by means of a horizontal frame between each, are caused to traverse backward and forward, a circular motion being at the same time imparted by means of a vertical crank-shaft pivoted to the central and upper part of the table and actuated by bevel-gearing; four other cranks, one at each corner of the frame, serve to guide and limit its motion, causing its central point to describe a circle about four feet in diameter, so that different portions of the faces of the upper and lower glass plates are continually applied to each other. Sharp river sand sifted into two different sizes is used as an abradant; when the surface of the lower plate has been ground quite flat by the coarser sand, it is removed by careful washing and the finer sand is substituted for it; to this succeeds emery powder, a coarser and then a finer quality being applied, the glass being thoroughly washed previous to each change of material, so that none of the coarser particles previously used may remain to cause scratches on its surface. The plates are then inverted, and the same process is repeated on the other side. For this purpose the frame above described is suspended by chains which admit of its being raised from the face of the lower table. These machines do not permit the use of very fine emery, as their weight and velocity at such near proximity as they would necessarily be would tear the surface of the glass; the velocity is consequently reduced when the finer emery is employed, and a different machine, worked by hand-power, is used for the final smoothing, preparatory to the process of polishing. This is effected upon stone benches about two feet high, having plane upper surfaces which are covered with wet canvas. Upon this one of the larger plates is laid, the wetted surface of the canvas serving to retain it in place. A smaller plate is used as a grinder or runner; if this be of such size that a uniform pressure cannot be imparted to it by hand, leaden weights are distributed over its surface. Emery powders of gradually increasing fineness are applied with water, and the runner is traversed back and forth by hand with a semicircular stroke, its path being slightly changed at each stroke, while the runner itself is gradually turned around as on an axis during the progress of the work. These combined movements serve to evenly distribute the emery and insure an equal amount of grinding both to the bed-plate and runner. Small plates are smoothed by young girls; for the larger sizes two women stand, one on each side of the bench, and by placing their outstretched hands on the runner give it a backward and forward movement of five or six feet.

About six sizes of carefully washed emery are used in smoothing, and between each change the plates and everything about the apparatus are carefully washed, including the hands of the operators. The fine emery powder last employed imparts a very smooth surface to the plates, which are now ready for polishing. The polishing-machine has a bed mounted upon rollers, and traversed slowly back and forth sidewise by a rack and pinion beneath. Two carriages supported on wheels at each end, which run on rails at each end of the table, have a reciprocation of about two feet by means of two opposed cranks, so that one advances as the other recedes. They are placed about four feet apart, and to their under surfaces are attached rubbers having sockets in their upper part, into which bars with rounded ends on the under side of the carriage are fitted, allowing a certain freedom of motion independent each of the other; they measure 6 × 8 inches. are placed at distances of one foot apart, and their faces are covered with thick felt. By the reciprocating motion of the carriage and the transverse movement of the bed, they are caused to act on every part of the surface of the glass, a sufficient pressure being imparted to each by weights.

The powder generally employed in polishing is "Venetian pink," a substance containing a small proportion of oxide of iron mingled with earthy matter. It is used with water, which reduces the friction and prevents the glass from becoming heated. Tripoli, crocus, and putty powders, when used with water, cut too actively to produce a high polish in this way; though they are employed dry for the last finish in hand polishing, the amount of surface acted on with the velocity and power of the machinery would render them liable to tear the face of the glass, beside exposing it to the contingency of being broken by the heat evolved.

Repolishing old plates which have been scratched is generally effected by hand, as the operation may be restricted to the scratched portion. The process is commenced with tripoli and finished with putty-powder or crocus. The rubber is attached to the end of a pole suspended from a spring, which affords the necessary pressure, and is pushed back and forth by a workman. This process is both tedious and laborious, and causes the surface to present a wavy and polished appearance much inferior to that of machine-polished glass.

Plate-hoist. A clamp or clutch by which a plate is lifted into position for attachment to the angle-irons forming the ribs or frames; or for getting the plates aboard for other parts of the work. It

Fig. 3811.

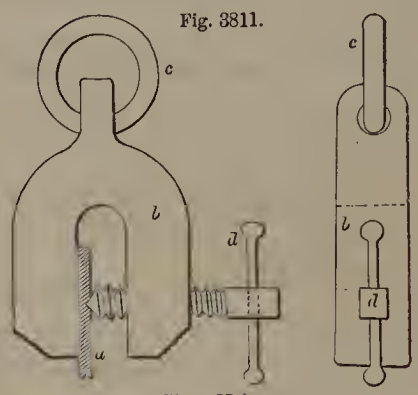


Plate-Hoist.

consists of a strong stirrup *b* and ring *c*, the latter being attached to the hook of the tackle. The plate *a* is clamped against one leg of the stirrup by the point of the set-screw *d*, which passes through the other leg.

Plate-hold'er. (*Photography.*) *a*. Also known as *dark-slide* or *slide*. That part of a photographic camera which is used to contain and transport the sensitized plate. It consists of a thin, flat, rectangular frame or box, square or nearly so, the dimensions of which enable it to take exactly the place of the ground-glass screen upon which the visible picture falls. The back of the plate-holder is provided with a door, which, when opened in the dark room, admits of the introduction or withdrawal of the collodionized plate. The front, that is, the side which faces the lens, has a thin sliding shutter, which serves to uncover the sensitive surface when the slide is in its place, so that it may receive the rays of light, the action of which forms the photographic image, exactly in the position occupied by the ground glass during the operation of focusing. By this contrivance the plate is taken to and from the camera in total darkness. *Inside frames* or *kits* are used within the plate-holder for making small negatives.

b. A pneumatic device used to hold the plate during development.

Plate-i'ron Gird'er. A girder made of wrought-iron plate, either rolled with flanges or built up of flat plates and angle-iron. See GIRDER. See also pages 1198, 1199.

Plate-leath'er. Wash-leather for rubbing and cleansing silver-plate and jewelry.

Plat'en. (*Printing.*) The slab which acts in concert with the bed to give the impression. See PRINTING-PRESS.

Plate-of-wind. (*Music.*) In the construction of organ-pipes, a thin aperture whence a sheet of air issues, impinging upon the *lip* of the mouth and receiving a vibration which is imparted to the column of air in the pipe. See PIPE; MOUTH-PIPE.

The word is sometimes applied to the issuing stream of air, which is flattened by the surfaces between which it passes, so as to impinge as a ribbon of air upon the edge of the lip.

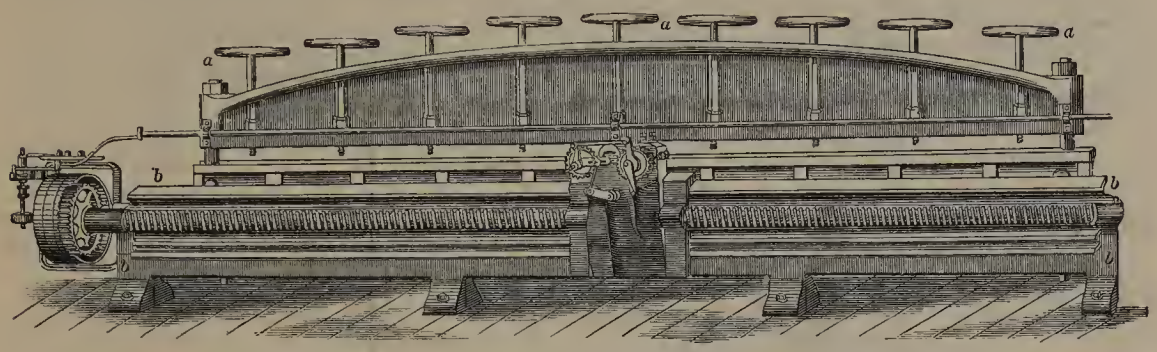
Plate-pa'per. Paper for taking impressions of engraving. *Copperplate*-paper.

Plate-plan'ing Ma-chine'. A machine designed for planing true edges and bevels on plates for boilers and for iron ships.

In the machine illustrated, the plate is clamped upon a wooden bed, 14 feet long, by means of holding-down bolts *a a*,

etc. The cutter-head is driven by a screw sliding on a pair of ways *b b*, one above the other. It is self-operating in feed, and has cutters which work each way. It bevels the edge and squares up a narrow calking surface. Ships' plates may be planed before or after bending. In the latter case the bed is curved to the form of the plate.

Fig. 3812.



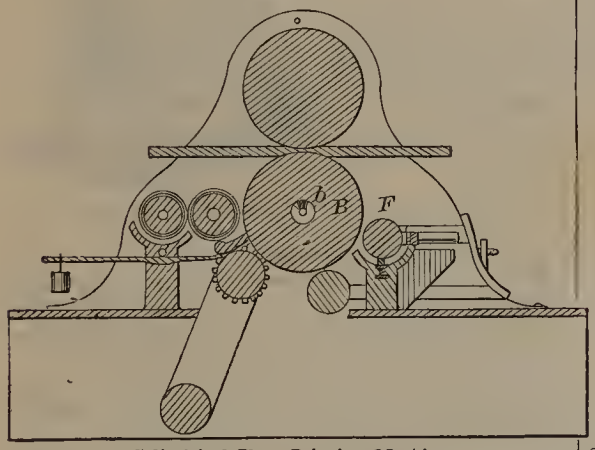
Sellers's Plate-Planing Machine.

Plate-pow'der. Rouge and prepared chalk or oxide of tin and rose-pink. Used in polishing silver-ware.

Plate-print'ing Ma-chine'. One for printing from plates or cylinders engraved in intaglio. Such plates have depressed lines made to contain ink, which is smeared all over the surface; the superfluity is wiped off, leaving the lines full; the surface is then polished and damped, absorbent paper being pressed against the plate during the passage between rollers. The ink leaves the lines and adheres to the paper.

Machines for this purpose have been made to operate upon plates, the inking-rollers being succeeded by wipers and polishers, after which the plate, on its bed, passes beneath a D-roller

Fig. 3813.



Cylindrical Plate-Printing Machine.

and returns. The plate is kept hot by gas or oil lamps beneath the bed or by iron heaters; a blanket between the impression-roller and the back of the paper gives a spongy but severe pressure, which forces the paper partly into the lines of the plate, whence it withdraws the ink as the paper is subsequently lifted. See COPPERPLATE-PRINTING, page 619

Another form of plate-printing press has the engraving on a roller *B* heated from the interior by a row of gas-jets *b*. The ink is applied by the roller on the left, which rotates in contact with the ink-distributing roller and the engraved cylinder on its respective sides. Beneath the inking-rollers is an ink-doctor, a knife edge which removes the greater portion of the superfluous ink. The cylinder then comes in contact with an independently revolving wiping brush-roller, then with a second wiper-roller, and next with a roller *F*, whose surface performs the duty performed in the hand-printing process by the palm of the hand, being surfaced with whiting for giving the final polish to the cylinder before it passes to the paper, which is pressed upon it by the roller above.

Plate-rack. A frame in which washed and rinsed dishes and plates are placed to drain.

Plate-rail. (*Railway Engineering.*) A flat rail.

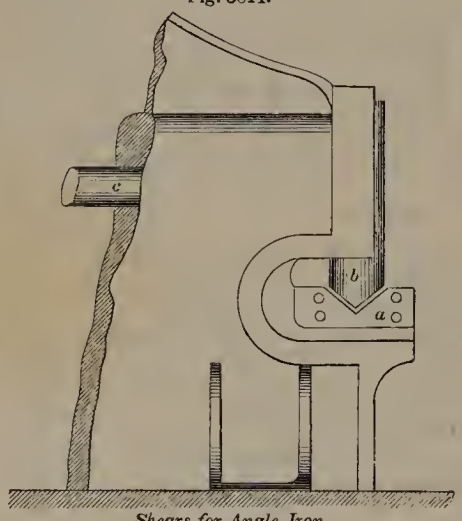
Plate-rail'way. A tramway in which the wheel-tracks are flat plates.

Plate-roll'er. A smooth roller for making sheet-iron.

Plate-shears. (*Metal-working.*) A shearing-machine for sheet-metal, such as boiler-plate. See SHEARING-MACHINE; BAR-SHEAR, etc.

A shears for cutting bent plates or angle-irons. The bed *a* and cutter *b* are adapted to the shape of the piece, so as to avoid bending or buckling, and the

Fig. 3814.



Shears for Angle-Iron.

cutter is operated by a cam on the shaft *c* or equivalent.

Plate-warm'er. A small cupboard standing in front of a fire and holding plates to warm.

Plate-wheel. A wheel without arms. One in which the rim and hub are connected by a plate or web. Many car-wheels are made in this way. The wheels of watches are made so, and the plate is afterward filed away in portions so as to leave spokes in the form of a cross. This is called *crossing-out*. A special file is used for the purpose.

Plat'form. 1. (*Fortification.*) The floor on which the guns are placed. It is level transversely, and has a slight slope toward the embrasure. The chassis, when pivoted forward, traverses on a curved track at the rear. The gun runs in and out of battery on the chassis.

2. A landing-stage.

3. A raised walk alongside a railroad-track, to

assist in mounting to or dismounting from the cars.

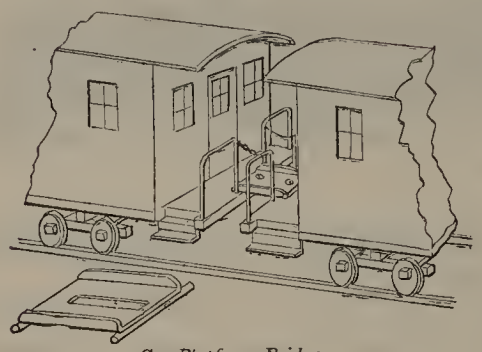
4. A floor supported by a scaffold.

5. The bench in a glass-furnace on which the pots are placed.

Plat'form-board. (*Ordnance.*) A side-board on an ammunition-carriage for forage. *Side-board; wing.*

Plat'form-bridge. (*Railway-cars.*) A gangway over the space between the platforms of adjacent

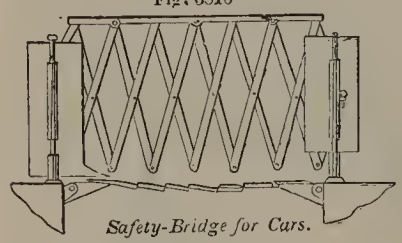
Fig. 3815.



Car-Platform Bridge.

cars in a train. It is a measure of safety, to prevent persons falling down between cars when in motion. In Fig. 3815 it is a gang-plank with arrangements to allow it to slip back and forth, but not slip off.

Fig. 3816



Safety-Bridge for Cars.

In Fig. 3816, the floor and sides of the bridge which unite the platforms of adjacent cars are made on the expanding lattice or lazy-tongs principle; they are contractible, to be taken on board, or are swung in on pivots when the cars are detached.

Plat'form-car. (*Railway Engineering.*) An open car having no inclosing sides, or merely surrounded by low ledges; intended for carrying stone, pig-iron, and similar articles of freight.

Plat'form-car'riage. (*Ordnance.*) One for transporting mortars. *Platform-wagon.*

Plat'form-crane. 1. A crane on a movable truck.

2. A crane on the *break* of a platform to land goods from wagons or cars.

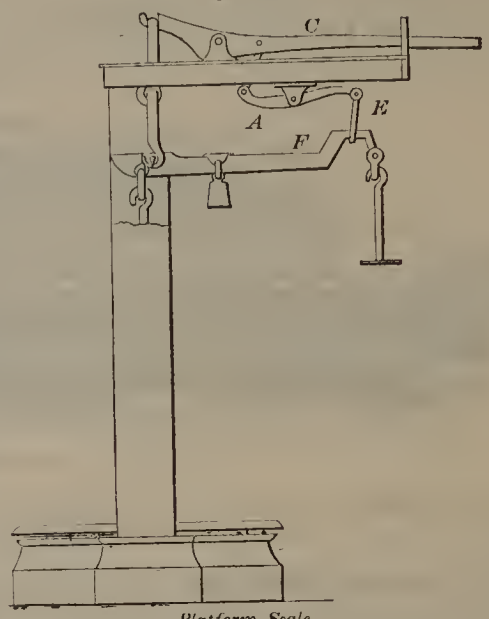
Plat'form-scale. One with a flat scale on which the object to be weighed is placed.

There are *counter* platform-scales of a comparatively small size. Larger ones are wheeled about on the floor of a store or warehouse, being adapted for weighing boxes, barrels, sacks, and packages which are moved by trucks. A still larger form is the cattle or hay scale, on which the wagon and its load are weighed at once, and the *tare* afterward deducted. See SCALES.

The principle is readily understood from Fig. 3817. The knife-edge of the scale-beam *F* rests in an arm depending from the lever *C*; this and the beam are connected by the pivoted lever *A*, its connecting rod and loop *E*, so that the beam may be maintained in horizontal position, and its vibrations instantaneously checked during the process of weighing.

A favorite form of British platform-scales is upon

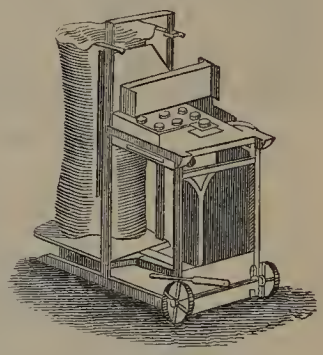
Fig. 3817.



Platform-Scale.

the lever principle, but unlike the steelyard. A constant proportion as to length exists between the respective ends. A number of weights are employed, which represent from four to ten fold their amount on the platform, according to the proportion established. It is portable, and is the ordinary scale of the country for weighing coal or produce in bags.

Fig. 3818.



British Platform-Scales.

Pla-til'la. A white linen Silesian fabric.

Plat'i-na. Twisted silver wire.

An iron plate for glazing stuff.

A metal. See PLATINUM.

Plat'ing. The art of covering baser metals with a thin coat of silver or gold was practiced by the Orientals and Egyptians many centuries before Europeans excelled in ornamental metallurgy.

The process is now extensively applied to the cheaper metals, those which are more oxidizable being protected by those which are less so.

The process originally practiced, known as *French gilding*, consisted in applying silver leaf to articles of brass or steel; the union of the two metals was effected by heat and by rubbing with a burnisher. This lacked the desired permanency, and was supplanted by the method still generally employed where electro-magnetic agency is not resorted to. As practiced at Birmingham, Sheffield, and other places where work of this description is largely carried on, the process is essentially as follows: An ingot, composed of an alloy of copper and brass, is prepared by melting the alloy in graphite crucibles, and pouring into two-part cast-iron molds, greased on the interior to prevent adhesion, and having a high gate or mouth-piece to give the pressure requisite to insure solidity and uniformity. After withdrawal from the mold the ingot is dressed with the file on one or both sides, according as it is to be single or double plated. A plate of silver $\frac{1}{40}$ the thickness of the ingot, and of slightly smaller dimensions, is then applied to its face, tied to it with wire, and a small quantity of a saturated solution of borax inserted around the edges. This salt melts at a low temperature, and excludes the air, which might otherwise oxidize the copper and prevent the union of the metals. The ingot is then transferred to the plating-furnace, and laid directly on the coke fire of the furnace, which has an iron door, provided with an aperture through which the interior may be viewed.

The operator watches at this hole, and when the proper soldering temperature is attained, which is known by the *riveting* or drawing together of the faces of the two metals, the ingot is instantly removed from the furnace; were it to remain a little longer an alloy would be formed, spoiling the plating. As it is, the metals are held in contact by the formation of a thin film of silver solder at their contacting surfaces. The ingot is then cleansed and drawn to the desired thickness between rolls.

In *plating copper wire* the silver is first formed into a tube one of the edges of which slightly overlaps the other. A red-hot copper cylinder fitting somewhat loosely is then inserted, and the two edges of the tube joined by rubbing with a steel burnisher. Its interior is then cleaned, and a copper rod on which it exactly fits is inserted; this is slightly longer than the tube, and is grooved at its ends, so that the ends of the tube by being pressed into these grooves may exclude the air: the compound rod is then heated red-hot, and the silver coating united to the copper by rubbing briskly lengthwise with the burnisher. The wire is then drawn to the required shape and thickness, being occasionally annealed during the process, and finally cleaned with dilute acid. Such wire is used for making bread-baskets and similar articles of utility or ornament.

Plated ware is formed by *raising* with the hand hammer, *spinning*, or on a large scale by stamping with counterpart dies or swages, and by punching

Gilding, in which a thinner coating of the gold is applied to metallic or other surfaces, is effected chemically, as in Elkington's or more properly Bonnet's process, by dipping the metal into a solution containing gold; or mechanically, as in *destemper*, *oil*, and *leaf* gilding, by applying gold-leaf on a surface previously covered with size or similar adhesive matter. *Water*-gilding consists in the application of an amalgam of mercury and gold, from which the mercury is afterward expelled by heat. Various modifications of these processes employed in surfacing articles with gold and silver have received different technical names, as German gilding, Grecian gilding, and Japanese gilding; in the latter a fine powder is used, producing a "deadened" appearance. See GILDING.

Silvering brass or copper may be effected by dipping the article in nitric acid to clean the surface, and then rubbing the surface with a composition of —

Cream of tartar	100
Chloride of silver	10
Corrosive sublimate	1
	111

Then polish. Thermometer scales are thus silvered.

Articles made of an alloy of silver and copper may be blanched by dipping them into a solution of bisulphate of potash. The acid dissolves out the copper and leaves the silver isolated.

Silver ma be *precipitated* on to a surface in a lustrous form by adding oil of cassia or cloves or a solution of grape sugar to a solution of certain salts of silver. Mix —

Aqua ammonia	30 grains
Nitrate of silver (crystals)	60 "
Spirits of wine	90 "
Water	90 "
	270 grains.

When the nitrate of silver is dissolved, filter, and add a solution of —

Grape sugar	15 grains
Spirits of wine	1½ ounces
Water	1½ "

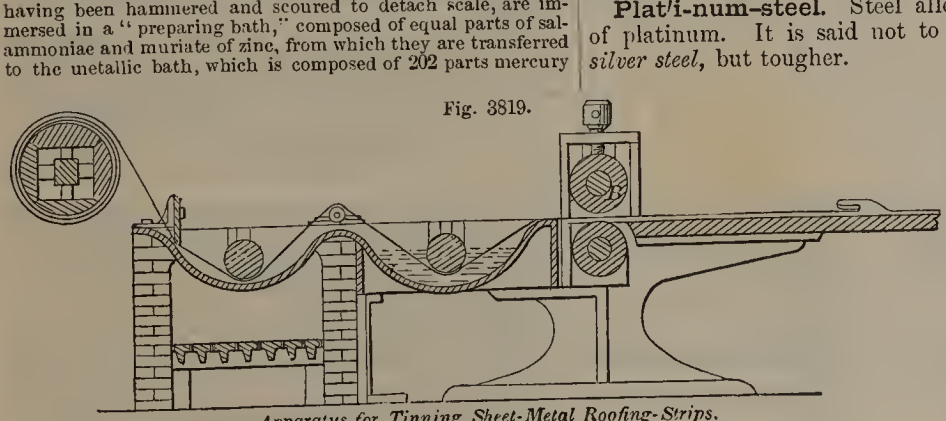
Leave the article in the solution for a day or two.

Tin-plate, commonly known as sheet-tin, but, properly speaking, tinned iron-plate, is made by dipping the plate, previously scoured bright and *pickled* by immersion in dilute sulphuric acid, into a bath of molten tin covered with a mixture of oil and rosin. Tinned iron wire is prepared in a similar way. See TIN-PLATE.

In Mallett's process for *covering iron with zinc*, the plates, having been hammered and scoured to detach scale, are immersed in a "preparing bath," composed of equal parts of sal-ammoniac and muriate of zinc, from which they are transferred to the metallic bath, which is composed of 202 parts mercury to 1,292 parts zinc, by weight, with the addition of about 1 pound sodium or potassium to each ton of the compound. The affinity of this alloy for iron being very strong, care must be taken to avoid too long immersion, which would dissolve the iron.

Fig. 3819 is a machine for covering with a soft metal a strip of roofing-metal made up of several sections joined together. The ends of sheets or strips of metal are interlocked, and the connected sheets then passed between rollers to close the seams, and then through a bath of molten tin or other soft metal, which coats the surface and closes and covers the seams, so as to form contiuuous pieces of indefinite length without appreciable or pervious joints.

Fig. 3819.



Apparatus for Tinning Sheet-Metal Roofing-Strips.

In *coating copper or brass vessels with tin*, they are first pickled with sulphuric acid diluted with about three times its bulk of water, then scrubbed with sand and water and washed dry. They are next sprinkled with dry powdered sal-ammoniac and slightly heated; a small quantity of melted block-tin is poured into the vessel, which is turned about until the inside is well covered, the excess being poured back into the melting-trough.

Iron is treated in a similar way, but requires more care, having less affinity for tin than copper If the vessel be greasy, it must be treated with strong muriatic acid. In old iron vessels, where the grease has penetrated the pores to a considerable depth, even this may fail to remove the grease.

An alloy of nickel, tin, and iron has also been employed for this purpose.

Plating German-silver table-ware with pure silver is effected by electro-magnetism. After removal from the coating-bath the articles are rubbed with a wire scratch-brush, and burnished with a steel burnisher wet with cream of tartar.

Græger's process of *covering iron and steel with copper* consists in first treating the object, previously well cleansed, with a solution of protochloride of tin and afterward with ammoniated solution of sulphate of copper; from the latter metallic copper is deposited, firmly adhering to the object, which may be afterward polished. Zinc and galvanized iron may be coated in the same way.

Gilbert's process of *coating hard metals with tin* or alloy consists in enveloping the metal to be coated, rolled into sheets of proper thickness, with a sheet of tin or alloy varying in thickness from .01 to .35 of that of the hard metal. The surface of the coating material is carefully rubbed smooth to prevent the formation of blisters or wrinkles, and the compound sheet is passed through polished rollers under a heavy pressure, by which considerable heat is generated, firmly uniting the surfaces of the two metals. The hard metal may also be tinned by immersion in a liquid consisting of one part by weight of nitrate or muriate of tin to about eighty parts of water; the time required varies from five to twenty minutes. See also ELECTRO PLATING; NICKEL-PLATING; GILDING; SILVERING; PLATINIZING; TIN-PLATE, etc. For list see METALLURGY.

Plat'i-niz-ing. The deposition of a thin film of platinum on to plate-glass; this is transparent when regarded by transmitted light, but gives a reflection, as from a mirror, when viewed from the side which has the stronger light upon it. See LOOKING-GLASS.

Plat'i-num. A white, heavy, ductile metal, very difficult to fuse, and resisting the action of heat and air and most acids. Equivalent, 98.7; symbol, *Pt*; specific gravity, 21.5; fusible under the oxyhydrogen blowpipe. It is a grayish-white metal, moderately hard (between copper and iron), ductile; welds at a white heat; almost infusible. Alloys readily with many metals; is non-oxidizable.

It is used for burners, chemical vessels, and tools, setting artificial teeth, bushing for guns, points of lightning-rods, etc.

Plat'i-num-steel. Steel alloyed with $\frac{1}{100}$ part of platinum. It is said not to be quite so hard as *silver steel*, but tougher.

Pla-tom'e-ter. An instrument for measuring areas on plans by mechanism. See PLANIMETER.

Platt. (*Mining.*) A cavity at the extremity of a level near a shaft, for collecting supplies of ore, which are placed in the *kibble* to be hoisted.

Plat'ten-ing Glass. The operation of forming glass into sheets or plates. In crown-glass this is effected by imparting a rapid whirling motion to the blown-out globe while still on the pontil. (See FLASHING.) Plate-glass is plattened by the roller, which forms it while still in a liquid state. The term is, however, specially applied to the operation of flatting cylinder-glass. In this case, the formed cylinder is cracked longitudinally by drawing a hot iron from end to end and dropping water on the heated line. A number of the cylinders are then introduced into a furnace, the cracked side uppermost, and when sufficiently softened each is taken up on an iron rod bent to a right angle and laid upon the flatting-stone, where it opens out and is smoothed down by an implement resembling a baker's peel, after which it is annealed. See GLASS; CYLINDER-GLASS; SHEET-GLASS.

Plat'ting. The top course of a brick stack or clamp.

Play. (*Machinery.*) *a.* A movement in a prescribed path; as the stroke of a piston, the oscillation of a pendulum.

b. Freedom of movement to a given extent to prevent binding. A certain looseness, as that of the arbors of watches between the plates, against which the shoulders abut. Known to watchmakers as *end-shake.*

Pleat'ing. See PLAITING.

Plec'trum. (*Music.*) An ivory instrument whereby the strings of the lyre were anciently struck. It survived till a late day in the *quills* of the harpsichord and its congeners.

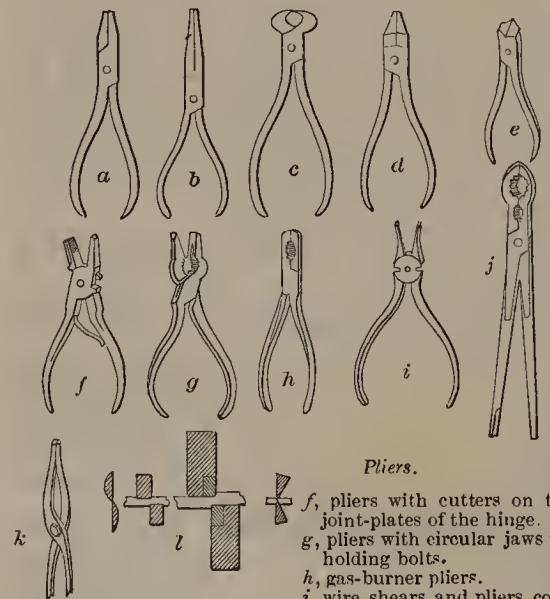
Pledg'et. 1. (*Surgical.*) A compress of lint flattened between the hands and laid over an ulcer or wound to exclude air, retain dressings, or absorb discharges. It differs from a tent in that the latter is a roll of lint introduced *into* a wound or ulcer to keep it from closing.

2. (*Nautical.*) A string of oakum used in calking.

Plensh'ing-nail. A large flooring-nail.

Plex-im'e-ter. A plate employed in auscultation, being placed in contact with the body to receive the blows of the hammer. See PERCUSSOR.

Fig. 3820.



Pliers.

a, flat-nose pliers
b, long flat-nose pliers.
c, cutting-pliers.
d, flat-nose pliers with wire-cutter on the side.
e, side-cutting pliers.
f, pliers with cutters on the joint-plates of the hinge.
g, pliers with circular jaws for holding bolts.
h, gas-burner pliers.
i, wire shears and pliers combined.
j, gas-pipe pliers.
k, long-nose pliers for blowpipe work.
l, figures illustrating action of pliers.

Pleyt. (*Nautical.*) A kind of river craft. *Playte.* (ADMIRAL SMYTH.)

Pli'ant. A French folding seat or chair.

Pli'ers. A small pair of pinchers with long jaws, adapted to handle small articles, such as the parts of a watch or other fine machinery. It is also specially adapted for bending and shaping wire.

Pliers with peculiarly shaped or proportioned jaws are called *long-nosed* pliers, *round-nosed* pliers, *cutting*-pliers, etc.

For special purposes, as *fishing*-pliers, *bottling*-pliers, etc. See Fig. 3820.

Plinth. (*Architecture.*) *a.* A square set off at the base of a structure or edifice.

b. The lower course or courses which project beyond the general face of a wall, giving it a wider base.

The plinth of a column is a square slab above the base and below the *dado.* When it has an upper receding member, it is a *double-faced plinth.*

Ploc. A mixture of hair and tar for covering a ship's bottom.

Plomb-brut. Rough lead.

Plon'gée. (*Fortification.*) The declivity of the superior slope of the parapet.

Plon'ket. A coarse woolen fabric.

Plot. A ground plan. A *plat.*

Plot'ting-scale. A scale, usually 1½ inches by 1½ feet, used in plotting ground. It is of brass, ivory, silver, or boxwood.

Plow. 1. (*Agriculture.*) An implement for making a furrow in land, the object being to stir the soil, make a bed for seed, cover seed, hill up earth to crops, lay out lines for planting trees or shrubs, and for other purposes, according to construction.

Excepting in the sacred records of the period before the flood, history gives no account of a time when man was destitute of the *hoe* and the *plow.* The history of one of these is the history of the other, for they had a common origin. In the distant past they were all of wood, and differed little except in size. We may safely assume that the hand implement preceded that drawn by animals.

The original hoe was a forked limb (*a*, Fig. 3821). This, being shaped a little, and the *tusk* being pointed, formed a plow (*b*). Byron refers to the plowshare by this name in his account of the storming and sacking of Ismail on the Danube, where Suwarrow swears, —

> "That shortly plow or harrow
> Shall pass o'er what was Ismail, and its *tusk*
> Be unimpeded by the proudest Mosque."
>
> DON JUAN.

c d are other shaped limbs in which the lower piece is formed so that its sole may run *on* the ground and turn a furrow, and not merely scratch the soil. *e* is an ancient Etruscan plow from an urn. *f g* are Japanese plows in the Smithsonian Institution; they show two degrees of ingenuity in advance of the other examples

The images of Osiris are represented with a plow grasped in each hand, and a harrow slung over the shoulder by a cord. See HARROW

"Osiris taught the way and manner of tillage and good management of the fruits of the earth. Isis found out the way of cultivating wheat and barley, which before grew here and there in the fields, among the common herbs and grass, and the use of them was unknown." — DIODORUS SICULUS.

The early deifications were many of them of individuals who had opened up sources of agricultural prosperity. *Isis* was the Greek *Ceres; Osiris* became *Bacchus*, the *Father Liber* of the erudite Pliny

The great efficiency of the engineering works believed to have been executed by Sesostris, about 1800 B C., indicates a great progress in the agriculture to which this scheme of irrigation was subservient. The alluvium of the valley of the Nile, however, never was plowed in the manner we consider essential to good husbandry on our soils.

"Some of the Egyptians lightly run over the surface of the earth with a plow, after the water is fallen, and gain a mighty crop without any great cost or pains." — DIODORUS SICULUS (60 B. C.).

The paintings in the Memphis pyramids show plows with one and others with two handles. It cannot be said that they pos-

sess a mold-board; they rather resemble our shovel-plow, and by going over the ground a sufficient number of times would have put light alluvial soil in a fair state of tilth to a depth of five inches. In the rich valley of the Nile, which receives an annual deposit of silt, a plow of this kind would produce its maximum effect. Poor as they are, they are substantially similar to those used at the present day in the greater part of Europe, as may be seen by a comparison of the plows in Fig. 3821. *h* is an ancient plow copied from Niebuhr, and is stated by him to be similar to the implement used to this day in Egypt and Arabia. With such tools, it was no wonder that Rome and Constantinople depended upon the alluvial valley of Egypt. *i j* are two wheeled-plows from Caylus's collection of Greek antiquities, and *k* is from an ancient Sicilian medal illustrated by Lasteyrie. *l* is a modern plow of Castile, and *m* is the plow now used in Sicily. It is hardly as good a one as that shown at *k*, which is a plow of the Greek occupation over 2,000 years since, before Syracuse fell under the attack of Marcellus, 212 B.C. It still lacks the mold-board. *n* shows the modern Roman plow, with a broad flat share. The diverging wings form a wedge which divides and turns over the soil to some extent. The plowman stands on the rear portion of the sill-piece and holds on by the post, adding his weight to increase the depth of furrow.

Fig. 3821.

Plows, Ancient and Modern.

This, perhaps, is the pioneer of sulky plows and buggy plows, as we of the West call them. *o* is from Strutt's plates of ancient dresses, and indicates the appearance of the Anglo-Saxon plow and plowman of the eighth century.

From the foregoing and those shown in the next figure, and a comparison of others for which we have no room here, it appears that the ancient Egyptian, Etruscan, Syrian, and Greek plows were equal to the modern plows of the South of France, part of Austria, Poland, Sweden, Spain, Turkey, Persia, Arabia, India, Ceylon, and China. The last thirty years may have worked a partial change, but not sufficient to invalidate the general truth of the statement. The ancient Etruscan plow, for instance, was probably as good an implement as the one now used by the peasantry of the Arno, — the same territory.

In Fig. 3822, *a* is a group from Beni-Hassan, and of about the date of Osirtasen, who is considered by Wilkinson to be contemporary with Joseph; he who stored grain during the seven years when the Nile exceeded its usual hight; when Osiris came forth with more than wonted vigor and spread beyond the usual cultivated area. The group has three men; the oxen are yoked by the horns, — a mode which is occasionally seen, but not so commonly as the neck-yoke. The plowman is assisted by a driver, and is followed by a man with a hoe, who breaks the clods. In some cases the plowman had a whip or goad, and

Fig. 3822.

Plows of Egypt and Syria.

no driver. Cows were much employed in plowing; men and asses also. Horses, never.

Another form of the ancient Egyptian plow is shown at *b* in the accompanying cut. The presentation of the share is different, much like our shovel-plow, but instead of connecting the stilts to the beam and having a pair of handles proceeding therefrom, the man grasps a stilt in each hand. Reins were not used in plowing in ancient Egypt, but are not uncommon in modern Egypt.

An illustration of the modern Syrian plow (*d*) is given to afford means of comparison. The share and mold-board in this more nearly resemble our form than do those of any other Eastern plow. The drawing is from Kitto. It is probable that his artist has improved on the original.

Figure *c* gives views of two yokes and the details of the modern Syrian plow. As before stated, it is rather of the shovel-plow order. The goad has a shovel at one end for clearing dirt from the share.

Osiris has the supremacy in all the deifications of ancient Egypt. Who he was that came to be so honored for his usefulness, that scores of centuries only added to his great fame, is now a matter of conjecture. He is represented with the instruments of tillage, and it is a reasonable supposition that he introduced great practical improvements in husbandry among this people of the Nile. As time rolled on, the name came to be transferred to the river itself, and Osiris the benefactor became a god, and the incarnation of the flood whose annual overflow was the life

of the land. No flood, no food; let the Nile stay within his banks for a few years, and the granary of the ancient world becomes a desert. Abraham went down there to buy bread; Isaac started for the same place for the same purpose, but put up with Abimelech at Gerar; Jacob and his family were saved alive in Egypt during another drouth, from which even Egypt was not exempt. Year by year, for seven years, to follow the metaphor of the people, Osiris (the Nile) rose in his vigor, and spread himself upon Isis (the cultivated soil), causing her to bring forth abundantly. In the excess of his virility he even embraced Nephthys (the barren ground of the desert adjacent to that cultivated), causing her to yield a fruitage.

"And in the seven plenteous years the earth brought forth by handfuls." Then followed a succession of years during which the overflow was stinted in quantity, and the land, missing its usual top-dressing, refused to repay the toils of the husbandman.

The periodical rise of the Nile commences about the first of June, continues for three months, remains stationary about twelve days, and then as gradually subsides. The rise is greatest in Upper Egypt, and less toward the mouth of the river.

The rise was less at former periods than now. In the time of Mœris, it is said that eight cubits were sufficient; fifteen or sixteen were required in the time of Herodotus, 456 B. C. At the present day eighteen cubits is considered the lowest inundation at Cairo. In the time of Pliny (A. D. 70) twelve cubits were a famine, thirteen scarcity, fifteen safety, sixteen plenty. At the present day eighteen cubits is the lowest, and at this hight the canals are cut, and distribution commences; nineteen cubits are tolerable, twenty adequate, twenty-one excellent, twenty-two abundant, and twenty-four ruinous to the houses and stores which are overflowed thereby. The rise toward the Rosetta and Damietta mouths may be about four feet.

The amount of mud left by the retiring Nile raises the cultivatable soil of Egypt about six inches in a century, at Elephanta. The land at that point has been raised about nine feet in one thousand seven hundred years; at Thebes about seven feet, and less toward the Delta. Many of the sites of antiquity are now buried, together with all kinds of débris lost and forgotten during the scores of centuries the river has rolled north to the Mediterranean, and annually rejuvenated the strip of land between the Eastern and Lybian Deserts. The cultivated land is gradually encroaching on the barren margin, except at points where the winds cross the mountain barriers, and bring deluges of sand from the desert. Buildings and monuments originally erected on the barren land outside of cultivation have now a depth of many feet around their bases.

The form of the ancient share is indicated by the words of Isaiah and Micah,

"Beat your swords into plowshares."

The change would consist in flattening a portion to enable it to throw the soil laterally, and then attaching the hilt to the stock at the most efficient angle. Had the comparison been made in our times, the change of "the sword to a colter" might have been suggested.

While Saul the son of Kish was yet a young king and was the head of a little band in Gilgal, 1093 B. C., the Israelites, who had no smiths, "went down to the Philistines, to sharpen every man his share and his colter, and his axe and his mattock." — 1 Samuel xiii. 20.

But little metal was used in ancient plows, and the statement is also true of those of later date made of the old forms. It is even within the memory of some of us that wooden mold-boards were used. The beasts of draft of old time were oxen and asses, but it was forbidden by the Hebrew law to plow an ox and an ass together. The mode of plowing was to make a second furrow just alongside of the one last made; having no mold-boards they did not throw up in *lands*, as we do. This mode gave its name to the mode of writing in the time of Solon (*boustrophedon*), in allusion to the writing of the lines alternately to the right and left, and left and right, and so on. This was in the transition of the language, when the people were changing from the mode of writing of the Phœnicians, from whom they received their alphabet, — not language, — from right to left, and were by the *boustrophedon* compromise approaching the mode adopted by almost all of their allies of the Aryan race. See Fig 3313, page 1655.

The usual team was a yoke of oxen, but the yoke was also used if other animals were employed. Even the harnessing of horses in Egypt and Mesopotamia was by a yoke. See HARNESS; CHARIOT. A pair of oxen was sufficient for the light implement; and when we read of "Elisha, the son of Shaphat, plowing with twelve yoke before him, and he with the twelfth," we are to understand that twelve teams and plows were in the field.

The unit of measurement of farming land was the quantity (*jugerum*) that a yoke (*juger*) of oxen would plow in a day; and we read of a time centuries before the period assigned to Romulus, that Jouatban and his armor-bearer killed "twenty men within as it were half the space which a yoke of oxen might plow" in a day. About one hundred and eighty years after the times of the scrimmage "over against Micmash," we find Hesiod writing about his farm in Bœotia and farming matters in general. These primitive plows must have been peculiarly inefficient in his land, which he describes as "bad in winter, hard in summer, and never good." The enthusiasm about Mount Helicon was and is exotic. Hesiod's recommendation to have an extra plow for use in case of accident seems well placed.

With such a tool it is no wonder the comparison was made in Luke ix. 62, of the worthlessness of the plowman who looked back in the middle of a furrow. Hesiod for himself, and Pliny, quoting from "heroic, Stoic Cato the sententious," say, "Never stop in a furrow, but drive right on." The same thing is often said in our own day in laying out lands or running off corn-ground, "Look ahead and do not try to true your furrow by looking back." This is true in fact, and in metaphor, as cited by the recorder, "the beloved physician," and by him of Tarsus, the epistolarian.

Varro mentions the double mold-board for ridging, and Pliny the single mold-board for covering the seed. It does not appear, however, that the mold-board was common at that time.

"The plowman," says Hesiod, "must be well fed, go naked in summer, rise and go to work very early, have an annual feast, proper rest, and for winter have a coat of kid-skins, worsted socks, and ox-hide boots." A good plowman, in the time of Columella (about A. D. 50), was worth about $300, or the price of eight acres of good land. The interest on money was about six per cent per annum at that time; the rate was fluctuating, and not legally prescribed. A good yield from the land at this time was 21 to 32 bushels of wheat per acre. In Varro's time (50 B. C.) wheat was worth from 32 to 44 cents per bushel. For convenience, the figures are rendered into our currency and measures. In Columella's time, wheat was worth $1 68 per bushel in Rome. Money invested in land yielded about four per cent per annum, and the land was worth twenty-five years' purchase, or twenty-five times its rental.

Agriculture declined from the time of Cato to that of Pliny. The best of the memoranda on husbandry compiled by the latter are from Cato and Varro. It revived in the part of Gaul called Rhætia, where reaping-machines were running in the first century A. D., as recorded by Pliny, and subsequently referred to by Palladius. The latter describes them in his "De Re Rustica," about A. D. 350, as driven by oxen and harvesting fields in one day. See REAPING-MACHINE.

From these authors we also find that the Gauls had mold-board plows, with and without wheels; ate good wheaten yeast-raised bread, "lighter," says Pliny, "than we have in Rome"; and this although the Romans dug down the chalk-hill Leucorgeum, between Naples and Puteoli, to get an artificial whitening.

Pliny says (A. D. 79): "Plows are of various kinds. The colter is the iron part that cuts up the dense earth before it is broken into pieces, and traces beforehand by its incisions the future furrows, which the share, reversed, is to open with its teeth Another kind, the common plowshare, is nothing more than a lever furnished with a pointed beak: while another variety, which is used in light, easy soils, does not present an edge projecting from the share-beam throughout, but only a small point at the extremity. In a fourth kind, again, this point is larger and formed with a cutting edge, by the agency of which implement it both cleaves the ground and, with sharp edges at the sides, cuts up the weeds by the roots. There has been invented at a comparatively recent period, in that part of Gaul known as Rhætia, a plow with the addition of two small wheels, and known by the name of 'plaumorati.' The extremity of the share in this has the form of a spade: it is only used, however, for sowing in cultivated lands and upon soils which are nearly fallow. The broader the plowshare, the better it is for turning up the clods of earth."

The action and object of plowing were well understood by the old Romans. As stated in the "Georgics," the purpose is to pulverize the soil, expose it to the atmosphere, and keep down weeds. Stiff soil was plowed four times for wheat; broken in spring, cross-plowed in summer, and twice in September. Richer ground was plowed three times, the earlier September plowing being omitted. Poor ground was only plowed twice for a wheat crop. They understood summer fallowing. Deep plowing was recommended.

A day's work in good soil was one *juger*, equal to four fifths of an English acre.

The modern plow with a share and mold-board intended to run in a certain track and lift a furrow-slice, which it upset against the previous one or completely reversed, seems to have been unknown till quite late times. The improvements of the last hundred years are probably greater than those of the previous thousand. and the tool is regarded as about perfect. Any great advances will now consist in the adaptation of machinery as a motor A number of forms are to be cited presently.

It would seem that until the time of the dearth in Egypt, 1708–12 B. C, the land was held by proprietors in fee; but under the skillful financiering of Joseph it reverted to the crown, the people thereon going into vassalage also. "Behold," says Joseph, "I have bought you this day and your land for Pharaoh." Thus the nation became changed from freeholders to lease-holders. The king's share was thereafter one fifth of the crop. This was for grain; for wine, the practice in a neighboring country was the reverse. "Thou, O Solomon, must have one thousand, and those that keep the fruit thereof two hundred."

Strabo says that in India the rent was one fourth of the produce. Evidence before committees of the British House of Commons, in 1814 and 1821, showed that the English rent was about the same.

The *hectemorii*, poor Greeks who cultivated the fields of the rich, only received one sixth of the produce before the time of Solon.

The *politor*, or renter of land under the Roman system, received from one fifth to one ninth of the produce; the landlord bearing all expenses, the tenant finding the labor. All on the farm, stock, tools, and seed, belonged to the landlord; the tenant was a workman. The modern system, where the landlord finds tools and fixtures, the tenant everything else, was not generally practiced in early Roman times, although the *coloni*, described by Columella, held under a tenure nearer the modern; but the amount of the landlord's share, being from four fifths to eight ninths of the product, shows the relation of the tenants was a base and slavish one. In most cases the slavery was destitute of even a flimsy pretext, and the peasantry were serfs on the land. Of course the custom of different provinces and of the regions nearer home differed in different times and places.

The food of the Roman farm-servants was according to exposure and kind of work Those who worked in fetters had four Roman pounds of bread per day in winter, equal to forty-seven ounces avoirdupois; five pounds in summer till the figs came in, when it was reduced to four pounds.

The grade of slaves who were not fettered had one bushel of wheat a month in winter and five pecks in summer.

Wine was allowed at the rate of forty-eight to sixty gallons a year; say a gallon a week. After the vintage, *lora* was used *ad libitum*. This was made by pouring water upon the pressed stalks and skins and re-pressing the cheese. The servants had also rations of olive-oil. The farm-servant also received a coat and a gown three and a half feet long, once in two years. Most of the inhabitants of Europe were serfs down to the sixteenth century. This is true, as to time, of a very large number of the peasantry of England, and the poor-laws of that country perpetuate it to a great extent. Excepting as to Russia, and to parts of Turkey, — the latter might as well be counted out as an anachronism on the face of Europe, — slavery survived longest in Scotland, where it was extinguished within the memory of people yet living. It was succeeded by eviction and deportation, which are no great improvement and are now the order of the day. The Scotch lord has no more bowels than Cato, who recommended to sell old and diseased slaves. The poor-law guardians, lacking a market, pay a bonus for their removal, and call it *emigration*.

In Lombardy the landlord pays taxes and makes repairs; the tenant provides cattle, implements, seed, and labor, and gives one half the produce to the landlord. In the Neapolitan territory the landlord has two thirds the produce. In Ohio and neighboring States the landlord receives one third. In Japan he receives one sixth.

The grain or produce rent, in contradistinction to the cash rent, is the more common mode of tenure throughout the Continent of Europe. In England it is on a cash basis. That country is rapidly drifting into the hands of a few proprietors. Thanks to the much-maligned French Revolution, the land of France is held in small freeholdings. The Hebrew land polity is the best yet.

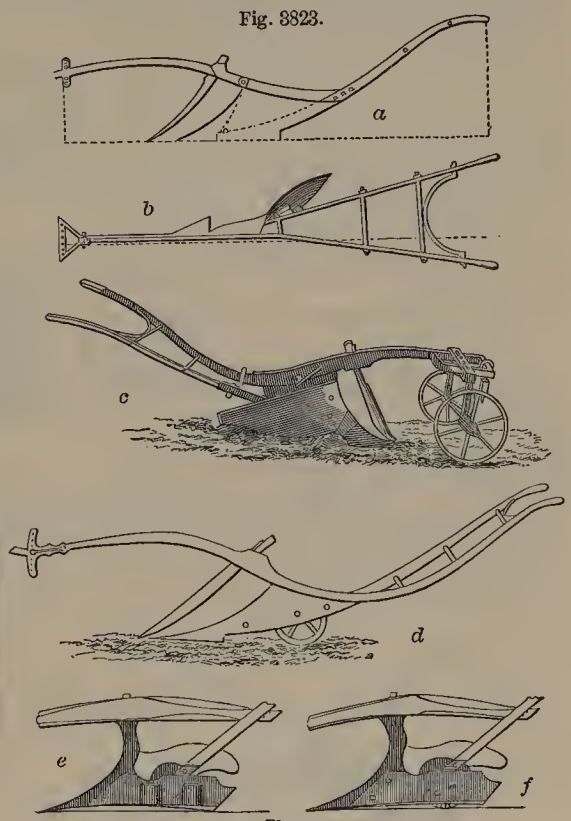
Passing over a long interval, we find that the modern plow originated in the Low Countries, so called. Flanders and Holland gave to England much of her husbandry and gardening knowledge, field, kitchen, and ornamental. Blythe's "Improver Improved," published in 1652, has allusions to the subject. Lummis, in 1720, imported plows from Holland. James Small of Berwickshire, Scotland, made plows and wrote treatises on the subject, 1784. He made cast-iron mold-boards and wrought-iron shares, and introduced the draft-chain. He made shares of cast-iron in 1785. The importation of what is known as the "Rotherham" plow was the immediate cause of the improvement in plows which dates from the middle of the last century. Whether this name is derived from Rotterdam cannot now be determined

The American plow, during the colonial period, was of wood, the mold-board being covered with sheet-iron or plates made by hammering out old horseshoes. Jefferson studied and wrote on the subject, to determine the proper shape of the mold-board. He treated it as consisting of a lifting and an upsetting wedge, with an easy connecting curve. Newbold of New Jersey, in 1797, patented a plow with a mold-board, share, and landside all cast together. Peacock, in his patent of 1807, cast his plow in three pieces, the point of the colter entering a notch in the breast of the share. Jethro Wood of Scipio, N. Y, patented improvements in 1819, and made the best plows up to date. He met with great opposition and then with much injustice, losing a competence in introducing his plow and fighting infringers. The peculiar merit of his plow consisted in the mode of securing the cast-iron portions together by lugs and locking pieces, doing away with screw-bolts and much weight, complexity, and expense. It was the first plow in which the parts most exposed to wear could be renewed in the field by the substitution of cast pieces.

Plows in Britain are divided into *swing-plows* and *wheel-plows*; the former being without wheels. *a b* in the annexed figure give the appearance in side view and plan of the Wilkie, Scotch, *wheel-plow*; the difference between it and ours is mainly in the greater length of the stilts or handles and the shape of the beam. It is usually made of iron. The mold-board is rather long and twisted, but this may vary with its adaptation to sod or stubble. A plow like that made by Gibbs of Canton, Ohio, will do either well. His mold-board is of such a shape that it may be molded on a cylindrical former.

The Scotch *wheel-plow c* has a forward carriage to regulate the depth of furrow, one wheel running on the land and the other in the furrow. They seem generally to have that wedge-formed, convex shape to the front portion of the mold-board, which with their long handles constitutes their most peculiar feature in our eyes. The long handles give the plowman great command, and if he were to ride on the handles as we do on ours in going over a cradle-knoll he would throw the share clean out of the ground. They will not be in favor except in countries long subdued to cultivation, as they take so much room to turn. We like a short plow, and hitch the team as close to the work as possible. This matter of hitching close was well illustrated during the late war. The old rambling way of hitching up a six-mule team with six feet distance between the pairs was discarded, and their traces and fifth chains were shortened in, so that they could almost browse upon the

Fig. 3823.



Plows.

tails of the span in advance, — as they did in fact. The old stiff tongue fourteen feet long, and the spans hitched up two or three paces apart, remind one of the practice not yet quite exploded in England, of hitching three horses, tandem fashion, to a plow, which was universal till Dawson of Frogden, Scotland, about 1770, showed how to place them abreast, for which the British farmers owe him a debt of gratitude, and after trying it fifty years to make sure it was all right, are prepared to pay on demand.

At the latter end of the eighteenth century, the level lands of Herefordshire and Radnorshire, Great Britain, were turned by plows which were rigged with wheels to obviate the necessity of a plowman. As usual at that time, the horses were hitched tandem, one ahead of the other, to the extent of three or four. A publication of that day (Housman's Travels, 1799) compares it with the superior husbandry of Norfolk, where horses were hitched abreast. The same writer states as follows: —

"I to-day observed a farmer sowing wheat near Abergavenny; a yoke of eight oxen were drawing one plow, attended by two men, one to drive the cattle and the other to manage the plow. Another yoke of eight oxen were drove up and down the ridges after plowing, in order to sodden or compress the earth, — an unnecessary operation. The farmer valued these oxen at £ 11 each, one with another. Their motion was extremely slow, and consequently little work was done in a day. In the same field, one man was sowing wheat and another harrowing with three horses, while the master sat on horseback directing the several operations of this posse."

Hitching horses by the tails to plows, harrows, and other implements was forbidden in Ireland by law in 1634. See HARROW.

In the United States we generally prefer a plow without a wheel, in England called a *swing*-plow. If this be rightly constructed aud adjusted, aud the team bc properly hitched and eveu-pulling, the plow will keep a level sole and throw an even furrow in level ground, requiring merely casual assistance from the plowman. The writer has used swing-plows in Ohio in clover sod, going round and round the field or the *land*, and no person touching tho plows except to turn them at the corners. To those not familiar with the practicc, it will be well to state, that in plowiug sod the whole field is frequently thrown into one land. The Ohio plow is generally left-handed, that is, throws the furrow to the left; thc near horse walks in the furrow, and the team is turned "gee" at the corners, 90° if it be a rectangular field.

After numerous careful trials of implements by the Agricultural Society of England, the committee determincd that the whecled plows had the advantage in point of lightness of draft, the difference amounting to from 10 to 20 per cent.

Plows with anti-frictiou wheels bchind the shares were invented almost simultaneously in England and Scotland, 1813–15. Wilkie's (Scotch) plow *d* of this class was invented in 1825. The wheel is journaled to run in the interval between the mold-board and landside, and answers in place of a sole, lessening the friction to a considerable extent. Wilkie's first plows of this descriptiou had a wheel whose flat rim ran upon the bottom of the furrow. In the one illustrated (Fig. 3823), the wheel has an inclination of 30°, and follows in the angle made by the colter and share, which is found to ensure greater steadiness.

The gain in draft on some plows by addition of the wheel has been proved by the dynamometer to be from 20 to 50 per cent. Much depends upon the construction and condition of the plow and the nature of the soil.

e f are two forms of the Green plow, one having a flat roller in the sole, and the other having also rollers journaled in the landside.

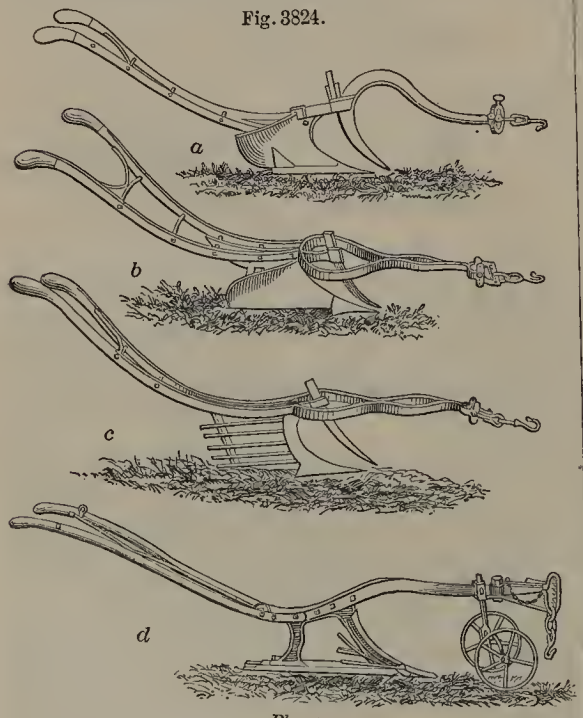
Plows with beams curved or divided to avoid catching stubble have been common in Britain for many years.

One of Finlayson's *rid-plows* (*a*, Fig. 3824) is made with a beam arched in front of the colter so as to avoid the lodgment of weeds or stubble in the angle usually formed at that point.

Another (*b*) has a beam bowed around the colter, so that the latter stands on a projecting piece, allowing any stubble to slide up and fall over without accumulating to such an exteut as to interfere with the turniug of the furrow.

Finlayson's *skeleton-plow* (*c*) is adapted for extremely tena-

Fig. 3824.



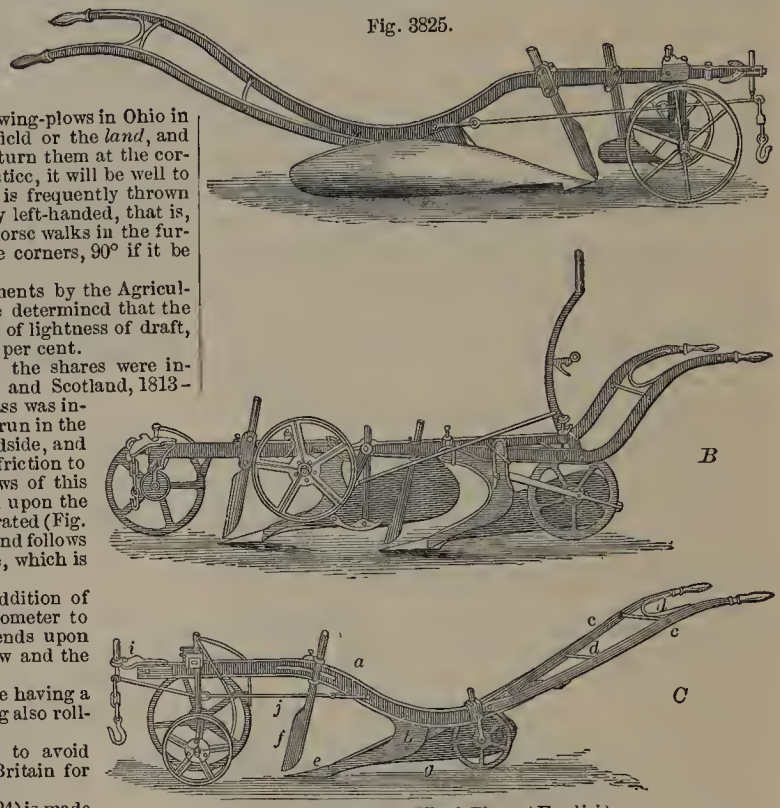
Plows.

cious soils, to lessen the friction of the furrow-slice upon the mold-board. It was designed to suit the soil of Kent County, England, and only expose one third the usual surface to friction.

Stothard (English) perforates the mold-board to reduce its frictional area in tenacious soils.

d is a potato-plow, having a share to pass below the tubers in the hill, and divergent arms to raise the soil and so scatter it that the tubers may be scrabbled to the top, separated, and left lying upon the surface.

Fig. 3825.



Hornsby's Wheel-Plows (*English*).

Fig 3825 is a view of three Hornsby's (English) prize plows. *A* is the champion model, having a small precedent share to turn over the stubble, a colter, and a share with a wing; the share gradually merges into a long, peculiarly shaped mold-board, which is convex and then concave, — a form not common with us. Of the pair of wheels, one runs in a furrow, the other on the land. The stilts are long, and great command over the plow is obtained by the leverage. Thc jointed draft-rod passes through an eye-bolt dependent from the nose of the beam, thence to the carriage of the wheels, and is bolted to the sheth of the plow at a point above the midlength of the mold-board.

B is a *double-furrow* plow; it has two plows stocked to a triangular beam. It has a gage-whcel forward, which runs on the land, and an anti-friction whcel which acts as the sole of the rear plow. The middle wheel is the turning-wheel, which runs clear of the soil in the space behind the forward plow, being only brought into action when the plow is to bc turned at the coruer of a *land*. When this is to be done, the lever, which is shown standing vertically, is depressed to the rear, throwing down thc turning-wheel into the furrow of the forward plow, raising the plow from the ground, and constituting the middle wheel a pivot on which the plow may be swung round, as on an axis, turning in its whole length. The plow may also travel to and from its work on this wheel. The depth of furrow is regulated by the hind wheel and the gage-wheel. The width of furrow is regulated by sliding thc hind plow-body on the frame of the implement.

The plow *C* is like the former in many points of eonstruction, but has a single body. Its adjustment for depth of furrow is by the hiud wheel.

The essential elements of a plow, in its primitive and in its varied modern forms, are, — a *share* to stir the ground: a *beam* by which it is drawn; and a *handle* or *handles* by which it is guided.

The modern plow has (1.) a wooden or iron frame or *stock*, to which the operative parts are attaehed, by which it is drawn through the ground, and to which the guiding handles are attached. The parts composing the stoek are, —

The *beam*.
The *sheth*, *standard*, or *post*.
The *handles* or *stilts*.
The *rounds*.

2. The operative parts are of metal, and consist of, —

The steel *share*, by which the bottom of the furrow is cut and the furrow slice raised.

The steel *colter*, by which the furrow-slice is severed from the land or unplowed portion.

The *mold-board*, by which the furrow slice is turned over.

The *landside*, seen in some of the figures but absent in others, which presses against the unplowed ground and serves to steady the plow.

3. The other attachments of the plow are, —

The *clevis*, for the attachment of the draft

The *draft-rod*, extending from the *clevis* to the *sheth*.

Many modifications are found.

The *colter* is sometimes a wing from the upper forward edge of the *mold-board*; or it is a cutting-wheel in advance.

The *draft-rod* is not universal, but adds to the strength of the implement.

The *mold-board* was, as its name indicates, formerly of wood. It was first made of iron by Small of Berwickshire, Scotland, about 1764.

The chilled cast-iron plowshare was patented by Ransome of Ipswich, England, 1803. The under side and points are hardened, and the top wears away, leaving a comparatively thin edge of hard, chilled iron. This is an imitation of the provision of nature, whereby the teeth of the rodentiæ are kept sharp, the external enamel keeping in advance of the softer parts which are sloped away from the cutting edge.

The points to be aimed at in the construction and management of a plow are as follows: —

A sharp, clean tapering form to the part which divides the soil.

A shape to the mold-board calculated to raise and turn the furrow-slice with as little friction as may be.

The beam and clevis should be so contrived that the team may be advantageously hitched in the line of draft Especial care is necessary when four or more horses are hitched, so that the draft of all may coincide.

The line of draft should be at right angles to the horses' shoulders, from whence it should pass through the middle hole of the clevis at the point of the beam.

The landside should be a plane, and parallel to the line of draft.

The colter should have an angular presentation of 45°.

The fin rising from the forward edge of the share, and acting in lieu of a colter, originated in Scotland.

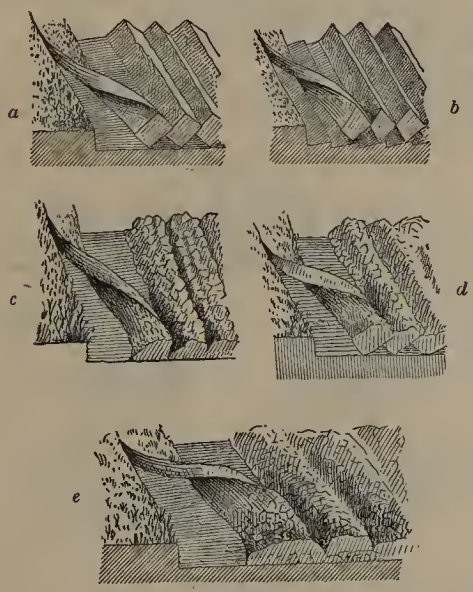
The cutting-wheel as a substitute for the colter is found in English paring-plows of many years back.

The depth and width of the furrow should be as 2 to 3.

The furrow-slice should be laid over at an angle of 45°.

Fig. 3826 represents different modes of turning furrows adopted in various soils.

Fig. 3826.



Plowing.

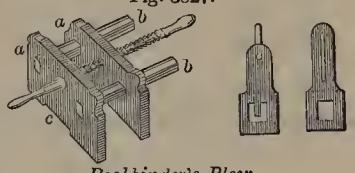
a is the preferable rectangular furrow with level bed
b is a crested furrow.
c has a completely inverted furrow-slice.
d shows ordinary plowing, the furrow-slice broken.
e is extra wide plowing with broken furrow.

Gang-plows are now used in some of the Western States, also to a large extent in England. They are simply four, six, or eight plowshares fastened to a stout frame. In California, on the lighter soils, eight horses draw a seven-gang plow, and one such team is counted on to put in six hundred and forty acres of wheat in the sowing season; or from eight to ten acres per day. A seed-sower is fastened in front of the plow. It scatters the seed, the plows cover it, and the work is done. The plow has no handles, and the plowman is, in fact, only a driver; he guides the team; the plows do their own work. It is a striking sight to see ten eight-horse teams following one another, over a vast plain, cutting "lands" a mile long, and when all have passed, leaving a track forty feet wide, of plowed ground. On the heavier soils, the process is somewhat different. An eight-horse team moves a four-gang plow, and gets over about six acres per day. The seed is then sown by a machine which scatters it forty feet, and sows from seventy-five to one hundred acres in a day, and the ground is then harrowed and cross-harrowed. When the farmer in this valley has done his winter sowing, he turns his teams and men into other ground, which he is to summer fallow. This he can do from the first of March to the middle of May; and by it he secures a remunerative crop for the following year, even though the season be dry. See GANG-PLOW.

2. (*Wood-working.*) A grooving-plane in which the adjustable fence is secured to two transverse stems which pass through the stock of the plane, and are secured by wedges or screws. It is fitted with eight irons of various sizes, and is used in making grooves in door-stiles to receive the panel, and for similar purposes. See PLANE.

3. (*Bookbinding.*) An implement for shaving off the edges of books and squares of boards. It consists of two cheeks *a a* connected together by two guides *b b*, and a screw passing through both cheeks. In one of the cheeks, at *c*, is fixed a cutting-blade. The book to be plowed is inserted between two boards in a press, the edges of the sheets projecting sufficiently, and one of the cheeks placed in a groove in the press, which serves to guide its motion. The plow is moved back and forth, and the cheek carrying the cutter advanced toward the other by turning the screw, cutting a longitudinal strip from the edge of the book at each forward motion until its whole surface has been planed off.

Fig. 3827.



Bookbinder's Plow.

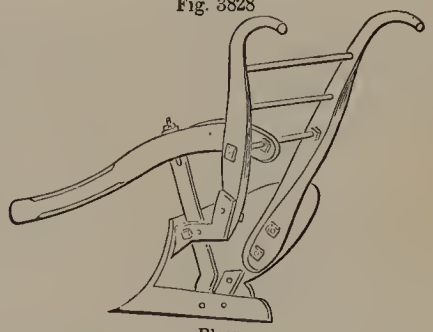
4. (*Weaving.*) An instrument for cutting the flushing parts of the pile or nap of fustian.

See under the following heads: —

Bar-share plow.
Binot.
Bog-cutting plow.
Breast-plow.
Carpenters' plow.
Corn-plow.
Cultivator-plow.
Diamond-plow.
Ditching-plow.
Double plow.
Double mold-board plow.
Double-shovel plow.
Down-share plow.
Draining-plow.
Expanding-plow.
Furrowing-plow.
Gang-plow.
Garden-plow.
Hillside-plow.
Hoe-plow.
Ice-plow.
Jumper-plow.
Marking-plow.
Mole-plow.
Paring-plow.
Prairie-plow.
Railroad-plow.
Reversible plow.
Ridging-plow.
Rotary plow.
Seeding-plow.
Shim.
Shovel-plow.
Side-hill plow.
Single-shovel plow.
Skeleton-plow.
Skim-colter plow.
Snow-plow.
Sod-plow.
Steam-plow.
Straddle-plow.
Subsoil-plow.
Sulky-plow.
Swing mold-board plow.
Swing-plow.
Tile laying-in plow.
Treble-shovel plow.
Turn-wrest plow.
Wheel-plow.

Plow-beam. That portion of the frame *A* to which the standard is attached and to whose forward end the draft is applied.

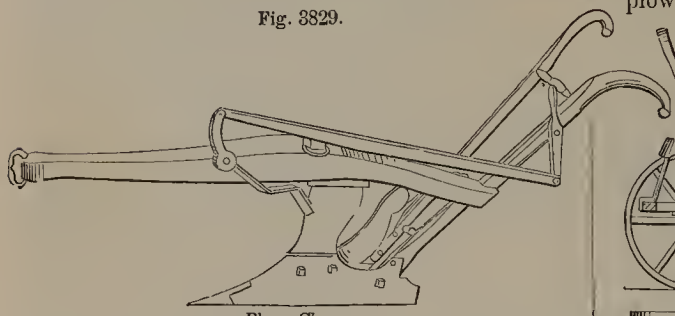
Fig. 3828



Plow.

Plow-clean'er. A long-handled thrusting implement by which the plowman may rid the plow of choking weeds, or the share of accumulated soil.

Fig. 3829.

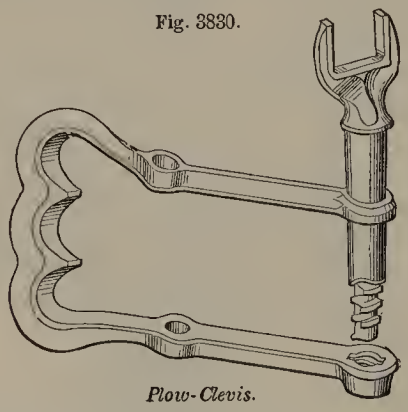


Plow-Cleaner.

Or, a vibrating clearer pivoted to the beam and operated by a handle to remove weeds from the front of the sheth.

Plow-cle'vis. The stirrup-shaped piece on the nose of a plow-beam, having three loops, in either of

Fig. 3830.



Plow-Clevis.

which the open ring of the double-tree may be placed, according to the depth of furrow desired.

Plow-head. The *clevis* of a plow. That part to which the draft is attached. The *muzzle* or *bridle*. The latter are names by which the clevis is known in Britain.

Plow-point. A detachable share at the extreme front end of the plow-body, forming an apex to the junction of the mold-board, sole, and landside.

Plow'share. (*Agriculture.*) *a*. The portion of a plow which cuts the slice loose below. The *colter* makes the vertical cut severing the slice from the *land*. The *mold*-board raises the slice and turns it over on edge. See Fig. 3831.

b. A triangular or heart-shaped blade on a shovel-plow to turn the earth over; and used in tending crops to throw the earth up to the stems of the plants. See SHOVEL-PLOW.

c. One of the blades of a CULTIVATOR (which see).

Fig. 3831.

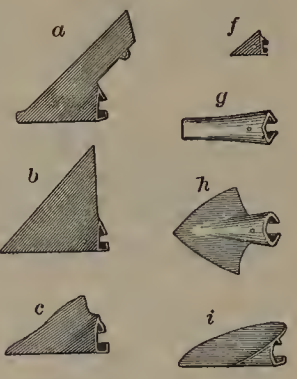
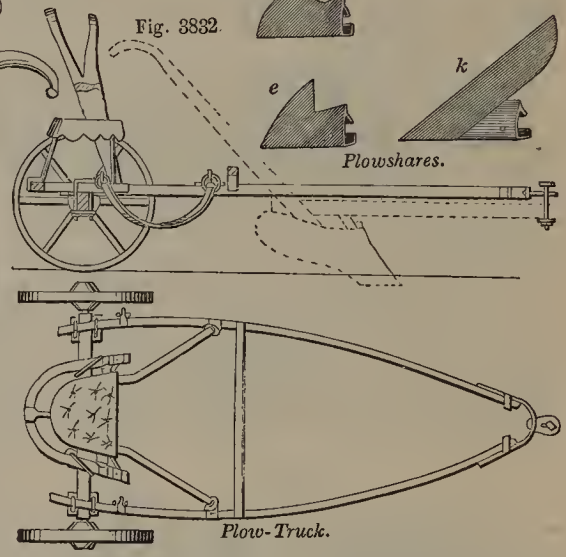


Fig. 3831 illustrates varieties of plowshares suited for different kinds of work.
a, for wide work.
b, for deep work.
c, for stony land.
d, for crested work.
e, for square work.
f, skim-coulter.
g, for subsoiling.
h, for ridging.
i, for setting out.
k, for paring.

Plowshares.

Plow-truck. A riding attachment to a plow.

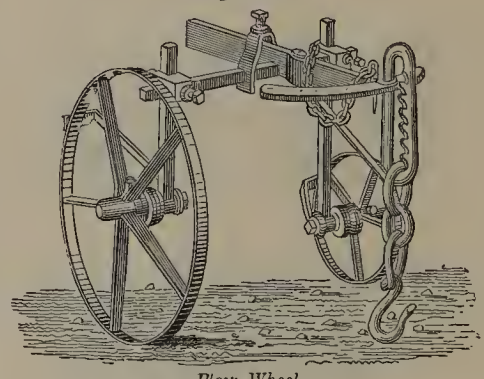
Fig. 3832.



Plow-Truck.

Plow-wheel. A wheel on the head end of a plow to limit the penetration of its share. In the illustration (an English pattern), one wheel runs on the *land* and the larger one in the *furrow*.

Fig. 3833.



Plow-Wheel.

Pluck. A two-pronged dung-drag.

Pluck'er. (*Worsted Manufacture.*) A machine for straightening and cleaning long wool, to render it fit for *combing*. It has a traveling feed-apron which, as it advances, delivers the ends of the long tufts to a pair of spiked rollers, which open the tufts and locks; it is thence introduced into a fanning apparatus whereby the wool is cleaned.

Plug. 1. (*Building.*) A block of wood let into a wall of brick or masonry, to afford a hold for nails in fixing the interior finishing.

2. (*Nautical.*) *a.* A conical piece of wood used to stop the hawse-holes when the cables are unbent.

b. A block to stop a hole made by a cannon-ball in a ship.

c. A stopper for the hole in a boat-bottom.

3. (*Steam-boiler.*) A stopper of metal which is placed in a steam-boiler or a pipe in communication therewith, and which melts at a certain temperature, so as to establish an exit from the boiler when the temperature and consequent pressure become dangerous. See FUSIBLE PLUG; HIGH-PRESSURE ALARM.

4. (*Die-sinking.*) A cylindrical piece of soft steel, whose end is turned to fit into a *matrix*. The indented (*intaglio*) design of the matrix is transferred to the end of the plug when the two are pressed forcibly together. The *plug* having the design in relief (*cameo*) is then hardened and becomes a *punch*, which is used to impress the faces of *dies* for *coining*. See MATRIX; DIE.

Fig. 3834.

Fire-Plug.

5. (*Stone-working.*) The plugs are inverted wedges with round backs placed in a hole which has been *jumped* in a rock; a *feather* or tapered wedge, being driven between the plugs, rends the rock. (*a*, Fig. 3834.)

6. (*Masonry.*) A dowel or cramp.

7. (*Railway.*) A wedge-pin driven between a rail and its chair.

8. (*Hydraulics.*) A *branch pipe b* leading from the *main* below the pavement and terminating at a point readily reached for the attachment of *hose*. This pipe is closed by a *cap* or *plug*, which is removed by a *spanner* when the hose is to be attached by its coupling to the thread on the pipe. A stop-cock on the branch pipe is reached by a turn-key introduced at an opening in the pavement.

Fire-plugs were first laid down in London in 1710. London was first supplied with water by leaden pipes in 1237. The water was brought from the Springs of Tyburn, a district long since included in the city, — not the city proper, but the metropolis as outsiders understand it. In 1613 Sir Hugh Middleton finished his aqueduct from Ware to London. This is yet called "the New River," and discharges into a reservoir at Islington, a northern suburb of London. The water was distributed by wooden mains and lead-pipe branches. Water-carriers still plied their trade in the reign of Queen Anne, supplying households from the public pumps, which were and are yet numerous, and yield abundant and excellent water.

9. (*Ordnance.*) The wooden stopper in the vent of a petard.

10. *a.* A small tompion in the muzzle of a musket-barrel.

b. The nipple of a gun.

11. (*Dentistry.*) A filling for a carious tooth.

Plug-cen'ter Bit. A bit having a cylinder instead of a point, so as to fit within the hole around which a countersink or enlargement is to be made.

Plug'ger. (*Dentistry.*) A dentist's instrument for driving and packing a filling material into an excavated hole in a carious tooth. They are of various forms, — hook, curved, or straight; with square, pointed, circular, edged, rounded ends; and with star, serrated, file-marked, and other terminations.

Some of the tools are pushed by the hand; others are driven, like a punch, with a mallet; a third form is automatic, and the pressure on the filling brings the mallet into operation. See DENTAL HAMMER.

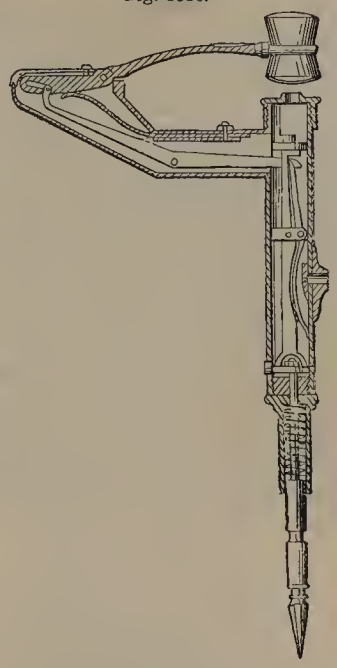
Fig. 3835.

Dental Plugger.

In Fig. 3835, the plugger has a pushing tool at one end and a hook-shaped pulling tool at the other, each operated upon by a hammer subject to the action of a spiral spring and other mechanism inclosed within the case.

In Fig. 3836, the pressure of the plugger upon the gold in the cavity of the tooth

Fig. 3836.



Dental Hammer.

gives movement to a vibrating hammer which strikes upon the extremity of the plugger. The intermission of the pressure permits the extension of the spring and raises the hammer.

The *electric mallet* is an automatic dental instrument for condensing the filling or plug in a tooth by a rapid succession of strokes imparted by means of electro-magnetism. The peculiar mechanism consists of a magnet or magnets, a pulsating armature, and a retracting spring with positive and negative wires and an automatic circuit-breaker. The magnet or magnets are arranged in the handle, and an armature vibrates in a case behind the bit.

The action of the armature makes and breaks the circuit. In one form, the plugger, being fast to the coils, partakes of the jar imparted to the plunger. In another form, the plunger has a sliding motion when struck by the armature hammer, and does not involve the coils in the jar of the blow.

In still another form, the armature is fixed, and the magnet, in modified form, vibrates within the case and delivers the stroke. The electric attraction in each case imparts the effective stroke. The wires incased in insulating material enter the handle end of the instrument, and by their flexibility permit its manipulation by the operator, who has simply to hold the bit in proper positions until the operation is completed.

The application of this instrument in larger size to stone-cutting and other work has been proposed.

Green's electro-magnetic mallet, manufactured by S. S. White of Philadelphia, for packing and condensing gold in filling teeth, strikes direct and very rapid blows, perfectly adjustable as to force, and either continuous or dependent upon *touch;* the blow being given when the point of the plugger is pressed upon the filling, and ceasing when the pressure is removed.

Among the ancients some success was obtained in the art of dentistry. Casselius was a dentist in the reign of the Roman triumvirs, and gold was used for the filling. Nearly 500 B. C. gold was thus used, and gold wire was employed to hold artificial teeth in position. A fragment of the tenth of the Roman tables,

Fig. 3837.

Green's Electro-Magnetic Mallet.

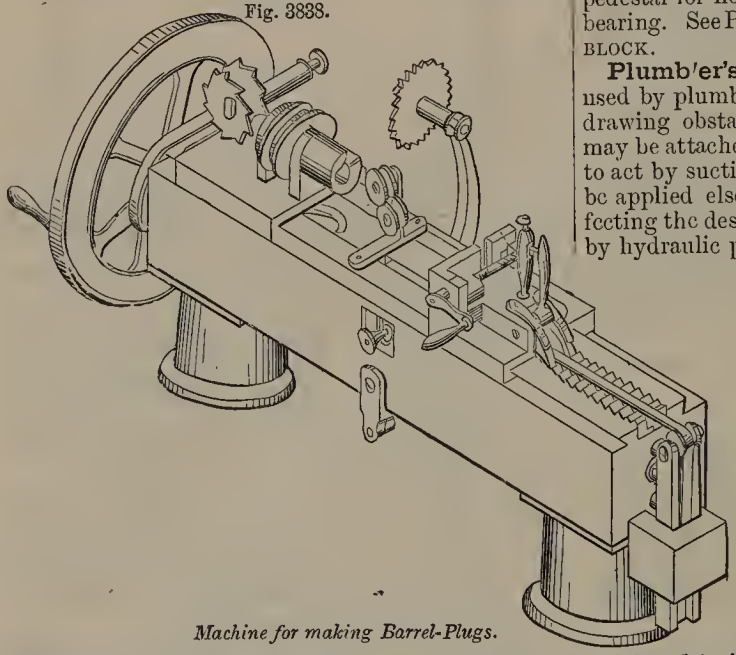
450 B. C., has reference to preventing the burial of any gold with the dead except that bound around the teeth. Herodotus declares that the Egyptians had a knowledge of the diseases of teeth and their treatment 2000 B. C. In Martial, Casselius is mentioned as either filling or extracting teeth.

Plug'ging. Pins driven into the joints of brick or stone walls to receive the nails whereby battens are fastened to the walls.

Plug'ging-for'ceps. A dentist's instrument used in compressing a filling into an excavated hole in a carious tooth.

Plug-ma-chine'. A machine for making wooden plugs for faucet-holes of beer and wine barrels. The stuff is clamped in a frame moved up by the sliding ratchet which acts upon a pawl. A similar pawl-and-

Fig. 3838.



Machine for making Barrel-Plugs.

ratchet holds the "feed" gained. A hollow, reciprocating revolving cutter shapes the plugs. An automatically descending saw severs them. At the rear of the cutter are two saws for tenoning the plugs. A lever raises the pawls on the clutch-frame to allow of its retraction.

Plug-rod. (*Steam-engine.*) *a.* A rod attached to the working-beam of a condensing-engine, for the purpose of driving the working-gear of the valves. Sometimes called the *plug-tree.*

b. The air-pump rod.

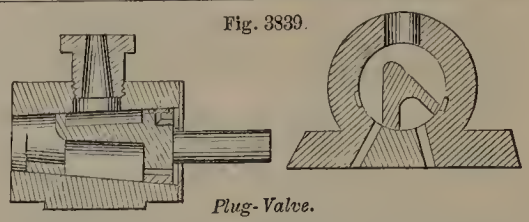
Plug-tap. A *master* tap. A cylindrical tap for cutting the dies of a screw-stock.

Plug-valve. A tapering valve fitting into a seat like a faucet.

Plumb. A line with a suspended plummet to prove the perpendicularity of work.

Plum-ba'go. A non-pertinent name for *graphite.* This name and that of *black-lead* were given

Fig. 3839.



Plug-Valve.

to it under the supposition that *plumbum* (lead) was its base. This turns out to be a mistake, as it is a form of carbon, and does not of necessity contain even iron, though a trace of the latter metal is often found in it. Samples of Ceylon *plumbago* are shown containing 98.55 pure carbon. See GRAPHITE.

Plumbago was formerly a monopoly in the Cumberland mines, but the mines of Russia, Ceylon, Ticonderoga, Greenland, California, Spain, and Bohemia have fortunately arrested imposition. See PENCIL.

Plumb-bob. A conoidally shaped piece of metal suspended by a cord attached to its upper end, and used for determining vertical, or, in connection with a level or straight edge, horizontal lines. It is indispensable in building operations, and is also employed by surveyors and astronomers for placing an instrument centrally over a station point of departure.

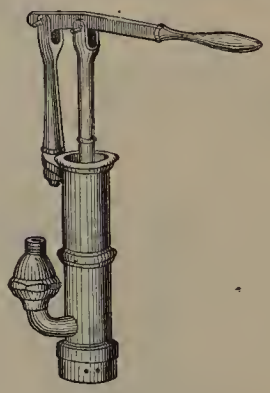
Fig. 3840.

Plumb-Bob.

Plumb'er-block. A pair of jaws or a pedestal for holding the brasses of a shaft bearing. See PILLOW-BLOCK and PLUMMER-BLOCK.

Plumb'er's Force-pump. A pump used by plumbers for testing pipe or withdrawing obstacles from a gorged pipe. It may be attached to the delivery end of the pipe so as to act by suction, or may be applied elsewhere, effecting the desired object by hydraulic pressure.

Fig 3841.



Plumber's Force-Pump.

Plumb'er's Sol'der. See SOLDER.

Plumb'ing and Sheet-met'al Work and Tools. See:—

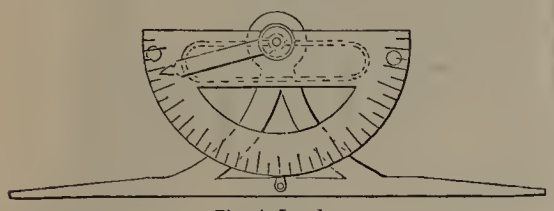
Autogeneous soldering.
Bat.
Beak-iron.
Blocking-down.
Came.
Copper-bit.
Creasing-tool.
Die.
Dinged work.
Double-seaming machine.
Dutch clinker.
Dutch tile.
Eave-trough.
Flagging.
Flashing.
Flux.
Fret-work.
Grozing-iron.
Latterkin.
Planishing-hammer.
Punch.
Raising.
Raising-hammer.
Riveting.
Riveting-set.
Seaming-tool.
Seam-set.
Share-hook.
Shears.
Sheet-metal press.
Snarling-iron.
Snip.
Solder.
Soldering-apparatus.
Soldering-furnace.
Soldering-iron.
Soldering-tool.
Spinning-metal.
Stake.
Striking-up press.
Teest.
Tin-scrap. Utilizing

Plumb-joint. A sheet-metal lap-joint in which the edges of the piece are simply laid over each other and secured by solder, without bending or *seaming*. A *lap*-joint soldered.

Plumb-lev'el. A level in which the horizontality of the base is determined by a suspended line with a plumb-bob. See LEVEL.

In the example, a plumb-level and protractor are combined in one. The base is a plane. The protractor swings by an axis coincident with its center, and a point on the base deter-

Fig. 3842.



Plumb-Level.

mines, in connection with the graduation of the protractor, the inclination of the object on which the base is placed. The index-finger is movable by its thumb-screw.

Plumb-line. The cord by which a plumb-bob is suspended.

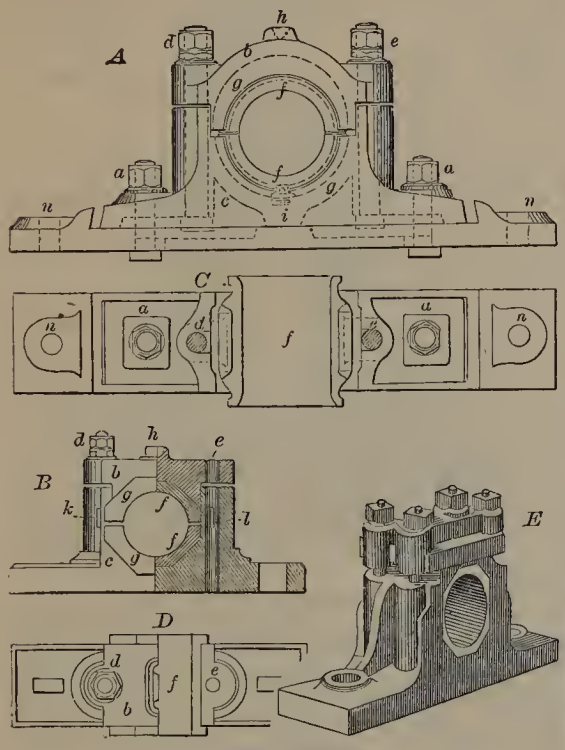
Plumb-rule. A narrow board with a plumb-line.

Plu-me'ta. (*Fabric.*) A Spanish woolen cloth.

Plum'mer-block. (*Machinery.*) An adjustable bearing for journals.

A B, Fig. 3843, are elevations (the latter partly in section) and *C D* plans of two plummer-blocks. That shown at *A C* is secured to a bed-plate *n* by screw bolts and nuts *a a*, the two parts *b c* of the block, when in position, being united by the screw-bolts

Fig. 3843.



Plummer-Blocks.

d e, by means of which they may be approached toward each other to compensate for wear of the soft metal lining *f*. This is composed of brass, Babbitt metal, or other composition inclosed within the hard metal casing *g*, which fits into a cavity in each of the parts *b c*, and is adjusted or removed by means of the screws *h i*. The bed-plate is made fast by bolts at *n n*. The general arrangements of the blocks *C D* are identical with those above described, but the lower half is fastened directly to its support by square bolt and nut or bolt and key connection; the bolts uniting the upper and lower halves are also keyed at *k l*. *E* shows a plummer-block in perspective. See JOURNAL-BOX.

Plum'met. 1. A pencil of solid lead.

2. A plug of lead for sounding. See SOUNDING.

3. A ball of lead for a plumb-line. An ordinary and simple device for uprighting a structure, a post, or what not.

The plummet is said by Pliny to have been invented by Dædalus, 1240 B. C. The vast edifices of the plains of Shinar and the Nile, not to mention the monuments of the more eastern civilization, contradict the statement of the Roman. It is, however, interesting to know the received opinion of the *literati* of 1800 years ago, and to this historian we are indebted for many details which appear to have been omitted as unimportant by contemporary writers. It is mentioned by Amos, 787 B. C., and by another Scripture author, 698 B. C.

Plum'met-lev'el. That form of a level having a suspended plummet in a standard at right angles to the base-piece. A *mason's* level. See LEVEL.

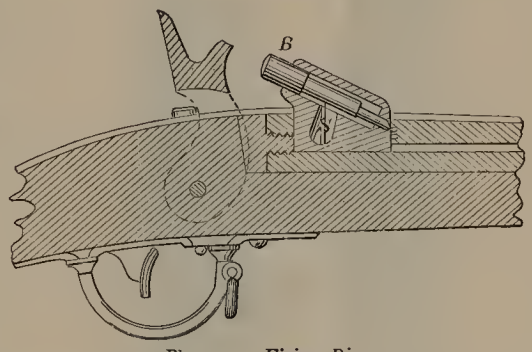
Plun'ger. 1. A long solid cylinder employed as a piston in a force-pump. See PLUNGER-PUMP.

2. (*Pottery.*) A boiler in which clay is beaten by a wheel into a creamy consistence. From this it passes to an *ark*, thence through sieves which remove nodules. The result is *slip*.

3. A form of striker used in some breech-loading fire-arms. A firing-pin.

The plunger *B* has a retaining spring *S* in the hinged block of the breech-loader. The spring is contained in a hole extending

Fig. 3844.



Plunger or Firing-Pin.

from the under side of the breech-block to the aperture in which the plunger works.

Plun'ger-buck'et. One without valve. See PLUNGER-PUMP, *E F*, Fig. 3845.

Plun'ger-pole. A hollow pump-rod of a CORNISH STEAM-ENGINE (which see). See also *G*, Fig. 3845.

Plun'ger-pump. One having a solid piston (*plunger*) which acts by displacement of the water in the barrel, in contradistinction to a bucket-pump which has a hollow piston (*bucket*) through which the water passes during the down stroke, to be lifted when the bucket rises.

A is one form of plunger-pump adapted for mines. The delivery-valve *b* is placed on top of the suction-valve *c*, which has a branch to the barrel *e* of the pump. The plunger-pole *a* is cased with a cast-iron pipe turned true and draw-filed, and works through a stuffing-box on top of the barrel.

B is a jack-head lift-pump introduced for the purpose of illustrating the distinction between *lift* and *plunger* pumps. It is also a form of mining-pump.

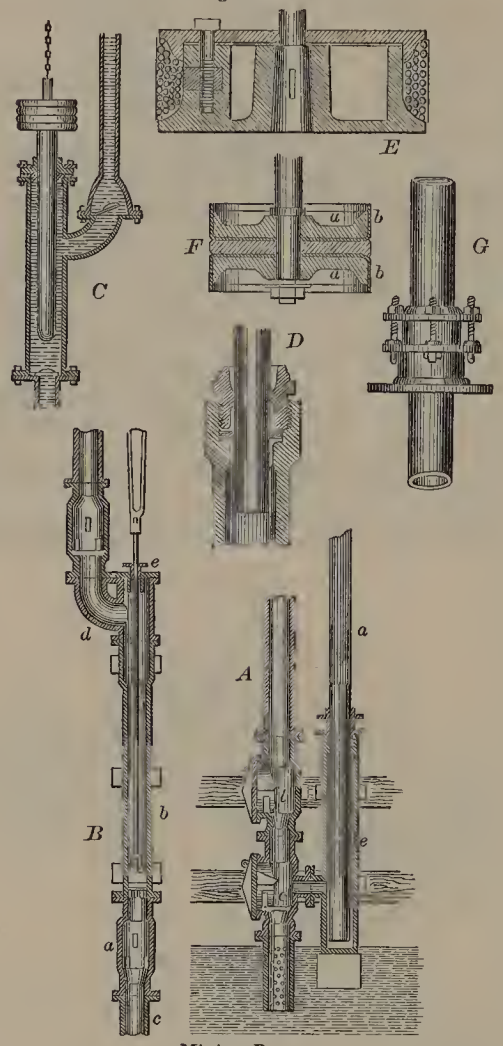
The working-bucket is packed with leather, which is secured to the body of the bucket by a brass ring. The suction-chamber *a* is bolted directly to the lower end of the working-barrel *b*, and has a suction-pipe *c* and windbore bolted to its lower flange. The *gooseneck d* (in which consists the peculiarity of the jack-head) is bolted to the top of the barrel, and has a bonnet and stuffing-box *e* through which the bucket-rod passes. The upper clack sits on the branch of the gooseneck, with the column bolted on its upper flange. The clack-chambers have doors through which the clacks are removed for repairs. A door is sometimes made in the gooseneck, through which the working-bucket may be taken out without taking off the bonnet

from the top Jack-head pumps are best adapted for lifting water from a cistern or a permanent *sump*, although they are very commonly used in sinking See MINING-PUMP; LIFT-PUMP; FORCE-PUMP, etc. See also list under PUMP.

C shows a pump with a loaded plunger.

D shows a piston fitting in the top of a pump-cylinder. The

Fig. 3845.



Mining-Pumps.

gland is screwed down upon the packing, which consists of two leather rings and one of metal.

E F are two plunger-pistons; one is represented as cast cylindrical, having a cap-plate screwed on to the bottom part.

Another is made up of circular disks *a* clamping rings of leather *b*.

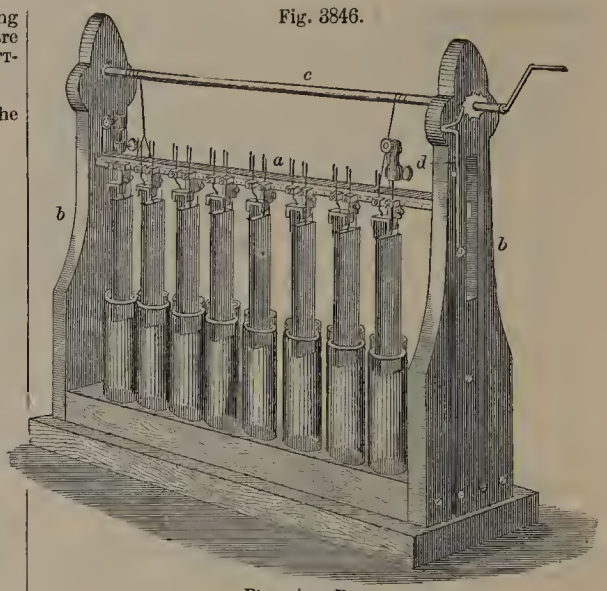
G is a portion of a plunger-pole, showing the coupling of sections.

Plun'ging-bat'ter-y. (*Electro-magnetism.*) A battery so arranged that the plates may be readily lowered into their cells, or raised therefrom when not required for use. In the arrangement (Fig. 3846), this is effected by attaching all the sets of the series to a horizontal bar *a* working in slots in the standards *b b*, and supported by cords attached to the shaft *c* provided with a crank, and a ratchet-wheel, which engages with a spring-pawl *d*, so that the plates may be held clear of the fluid in the cups or immersed therein to any desired depth.

Plun'ging-fire. (*Gunnery.*) Shot fired at an angle of depression below point-blank.

Plush. (*Fabric.*) A shaggy pile-cloth of various materials. *Shag.* An unshorn velvet of cotton, silk, or mixed fiber. Sometimes of a silk nap and cotton back. It has two warps, one of which is

Fig. 3846.



Plunging-Battery.

brought to the surface to make the nap. The warp is gathered in loops by wire, and cut in the manner of velvet.

It is composed regularly of a woof of a single woolen thread and a double warp; the one wool of two threads twisted, the other goat's or camel's hair. Some imitation *plushes* are made of other materials.

"Put on my new, fine, coloured cloth suit, with my cloak lined with plush, which is a dear and noble suit, costing me about £17."—PEPYS's *Diary*, October 26, 1664.

Plush-cop'per. (*Mining.*) A miner's name for *chalcotrichite*, a fibrous variety of red copper-ore, which occurs in reticulated capillary crystals of red color.

Plu'vi-am'e-ter. A RAIN-GAGE (which see).

Ply. 1. (*Fiber.*) A fold, twist, or plait.

a. A strand in a rope.

b. A thickness or fold in a carpet.

2. (*Nautical.*) To work against the wind.

Ply'ers. 1. (*Mechanics.*) A kind of balance used in raising or letting down a drawbridge.

2. A form of grasping tool. A small pinchers. See PLIERS.

Pneu-mat'ic Bat'ter-y. A contrivance invented by Mr. Taylor of Dublin for exploding a blasting-charge in mining operations. A priming of mingled white sugar and chlorate of potash is placed over the charge, and connected by a siphon tube with a vessel containing sulphuric acid; another tube connects this vessel with an air-pump placed at a convenient distance for the safety of the operator. On working the pump, a blast of air is forced through the tube, carrying with it a portion of the sulphuric acid, which inflames the chlorate mixture, igniting the gunpowder.

Pneu-mat'ic Cais'son. One which is closed at top and sunk by the exhaustion of the air within or by the weight of the masonry built thereupon as the work progresses. Such caissons are necessarily provided with air-locks to prevent the escape of the air, which is forced in at a pressure equal to that due to the water pressure at the depth to which the caisson may be sunk.

Those used by Captain J. B. Eads for the piers of the St. Louis bridge had central shafts 10 feet in diameter, around which the masonry was laid as the caisson descended. The shafts were open at top, and had but a single air-lock, which was at the bottom. See AIR-LOCK; CAISSON.

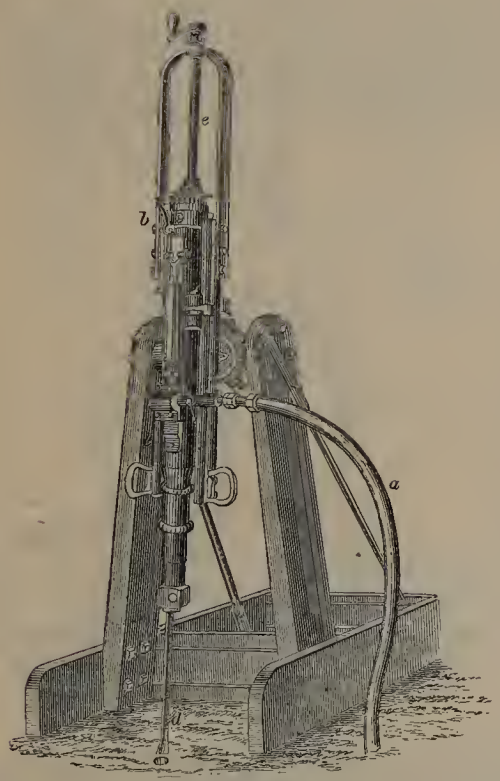
Pneu-mat'ic Car. A car driven by compressed air contained in reservoirs, which are filled by means of air-pumps. This application of compressed air is important as affording a means of dispensing with animal power on street railroads, and has been applied in practice with a certain degree of success. The cars employed in Chicago have four hollow tanks between the ceiling and roof, having a capacity of 150 cubic feet. The air is condensed to a pressure of 260 pounds to the inch, and drives two small engines, one on each side, at one end of the car. These are controlled by means of a wheel adjacent to the brake-wheel and immediately under the hand of the conductor. See STREET-CAR.

Pneu-mat'ic Dis-patch'-tube. See PNEUMATIC TUBE.

Pneu-mat'ic Drill. A drilling-machine operated by compressed air admitted alternately above and below a piston connected with gear-wheels which rotate the drill. The air-reservoir and force-pump may be placed at any required distance from the cylinder, and connected therewith by a flexible pipe.

Fig. 3847 is Burleigh's pneumatic drill. *a* is a pipe by which air is brought from the compressed air-chamber; *b c*, the cylinder, provided with proper valves for admitting the air alternately above and below the piston and for exhaust. The drill *d* is

Fig. 3847.



Burleigh Drill.

attached directly to the piston-rod, and is driven down by the admission of air above the piston, and retracted when the air is admitted below, giving from 150 to 250 blows per minute. The cylinder, with the piston and drill, is advanced by the screw *e* as the drill penetrates the rock, the drill being rotated at the same time. Five sizes of drill, forming holes from 1¼ to 5½ inches diameter, may be used, the engine being of about three horse-power with a pressure of 50 pounds to the square inch. A small amount of power is lost by the transference of the air from the surface of the ground when the apparatus is employed in subterranean operations in mining or tunneling, but this is more than compensated by the cooling and ventilation effected by the exhaust. The cylinder, with its working apparatus, is rotatable vertically on trunnions for varying the direction of the blows given by the drill.

By the *pneumatic drill*, the Mt. Cenis Tunnel, seven miles in length, was bored through the Alps. The Hoosac Tunnel in Massachusetts, five miles in length, was cut by the same means. Compressed air is also used in the St. Gothard Tunnel in Switzerland, lately commenced, which is to be 13 miles in length; and also in the operations at Hell-Gate, East River, N. Y. See SUBMARINE EXCAVATION; TUNNEL.

Pneu-mat'ic El'e-va'tor. A hoisting device in which compressed air is the agent for lifting. See PNEUMATIC HOIST; FURNACE-HOIST.

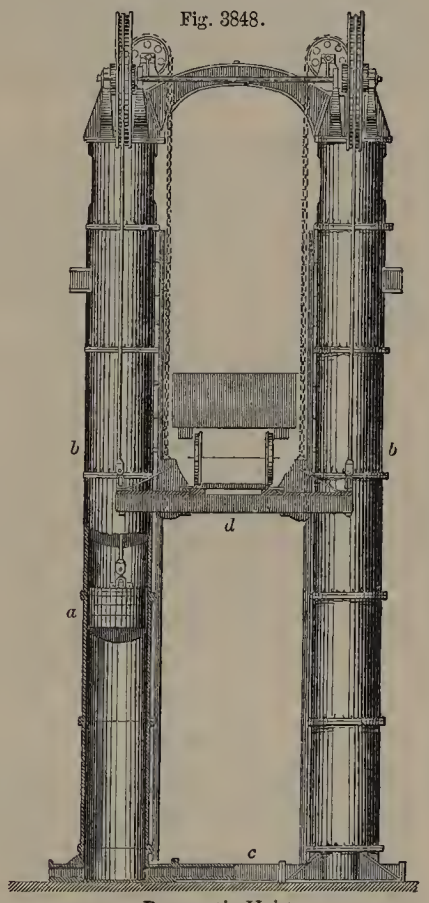
In planing-mills, the pneumatic method is used to carry the shavings from the planers to the furnaces of the steam-boilers; in grain and wool houses, to convey the stock.

Pneu-mat'ic Ham'mer. A hammer in which compressed air is the agent for lifting the helve or the head. See ATMOSPHERIC HAMMER.

Pneu-mat'ic Hoist. An elevating apparatus in which a platform is lifted by suspension chains passing over drums and thence to pistons working in vertical tubular shafts.

In the apparatus used at the Ayresome Iron Works, Great Britain, the cast-iron pistons *a* are packed with double cupped leathers, and are worked by creating a plenum above or a partial vacuum below, according as the elevating-table *d* is required

Fig. 3848.



Pneumatic Hoist.

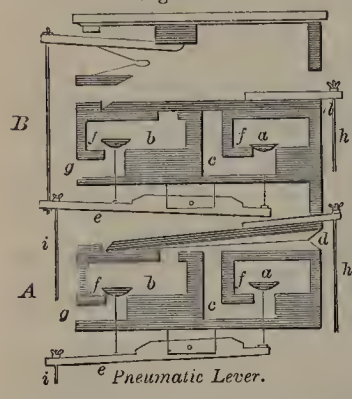
to be lowered or raised. For lifting ordinary loads, from 15 to 16 tons, an exhaustion equal to about 6 pounds per square inch is required; a plenum of about 4 pounds brings the table down. Two engines coupled to a crank on the shaft, which has on its ends a pair of opposite cranks, operate two single-acting air-pumps, which exhaust from one pipe and deliver into another, each of which is connected with a casing fitted with a slide-valve, so that it acts alternately for exhaust and delivery. The two cylinders *b b* communicate by a pipe *c* at bottom.

Pneu-mat'ic Le'ver. (*Music.*) A device invented by Barker of Bath, England, in which the elasticity of the air itself is made to overcome the resistance of the valve. The valve, being kept to its seat by a spring and the pressure of the air in the wind-chest, requires a certain expenditure of force to withdraw it from its seat on the *sound-board*.

The pneumatic lever admits air from the wind-chest to overcome the resistance to the action.

In Fig. 3849, *A* is in open and *B* in closed position. The two chambers *a a b b* are connected by an intermediate passage *c c*, opened or closed by means of the bellows *d d*. Each key of the instrument is connected with its appropriate lever *e e*, and on being struck depresses one end of this lever, lifting one of the valves *f f f f* and admitting air to the bellows *d d*, which carry a lever to whose projecting end is attached a rod *h h*, connected with one of the valves of the wind-chest; this is by this means pushed from its seat, allowing the air compressed in the chest to flow to the proper pipe. On withdrawing the finger from the key, a reverse action of the valves is produced, as shown in the upper figure, the air from the bellows escaping into the chamber *b* and making its exit through the passage *g g* to the outer atmosphere. *i i* are the rods connecting the keys with their appropriate levers. In consequence of the width of the device, about three inches, every fifth lever is placed in the same row, the whole forming five tiers.

Fig. 3849.



Pneumatic Lever.

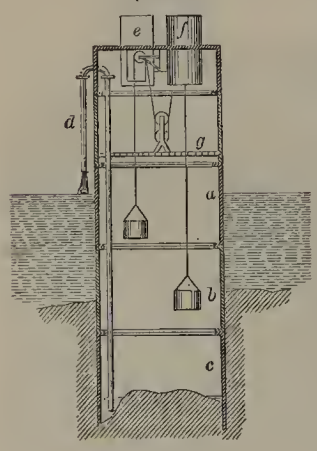
Pneu-mat'ic Par'a-dox. That peculiar exhibition of atmospheric pressure which retains a valve on its seat under a pressure of gas, only allowing a film of gas to escape. It is supposed to be owing to the thin film of escaping gas or vapor that passes out all round the disk, creating a partial vacuum, by which the disk is held on to its seat by the atmospheric pressure on the outside of the disk.

Pneu-mat'ic Pile. (*Hydraulic Engineering.*) *a.* A hollow iron cylinder or tube closed at its upper end, with the exception of an aperture, through which passes a pipe connecting the pile with a receiver. The receiver communicates with an air-pump, and by exhausting the air when the pile is in position over the spot where it is to be sunk, it is caused to penetrate the bottom; the mud, sand, or other deposits through which it passes being withdrawn and discharged into the receiver, while the pile is forced down by atmospheric pressure.

This method was patented by Dr. L. H. Potts in 1843, and through its means piles were secured in the hard bottom of the Goodwin Sands, off the coast of Kent, England, after passing through 75 feet of sand.

The pile is filled with concrete, and the inventor also proposed the injection of chemical solutions at its foot to consolidate the sand and form a firmer foundation.

Fig. 3850.



Pneumatic Pile.

b. A caisson with a means of excluding water, so that excavations may be carried on in the submerged end. It was first used in France.

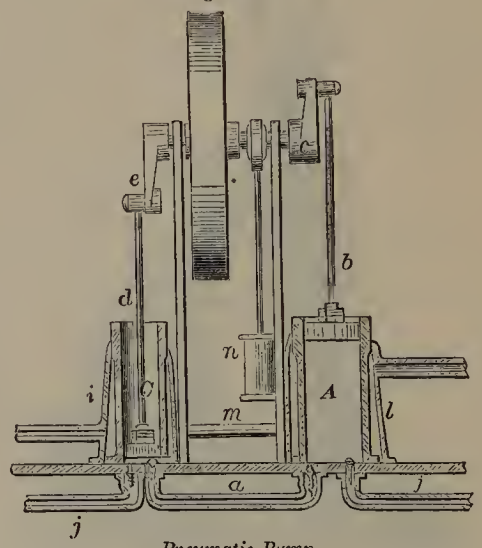
A mode of sinking cylinders for foundations by means of compressed air, as shown at Fig. 3850, was adopted to meet difficulties incident to building a bridge over the Medway at Rochester, England. It was at first intended to sink the hollow cast-iron piles for the piers by means of the exhaustive process, but the remains of an old timber bridge imbedded in the mud of the river rendered this impossible.

This foundation cylinder is composed of several sections, as *a b c*, bolted together through interior flanges; the edge of the bottom section is beveled, that it may more readily penetrate the ground. The top may be either dome-shaped or flat, and strengthened by interior transverse ribs or braces. *d* is a siphon through which water is discharged by the pressure of the condensed air; *e f*, air-locks through which the workmen enter and return and supplies are introduced; *g*, a platform for the hoisting apparatus, which removes excavated material. The cylinder has a supply-pipe and valve for introducing compressed air, a safety-valve, pressure-gage, and a large escape-valve for discharging the compressed air suddenly when required. The operation of sinking is as follows: a sufficient number of sections being bolted together to reach the bottom are placed in position, and, the air being allowed to escape, the cylinder sinks until bottom is reached; air is then forced in, and workmen are sent down who excavate the material beneath to as great a depth as possible; this is removed by the hoisting apparatus and passed out through the air-locks. When this is effected the workmen withdraw, the escape-valve is opened, and the water rushes in, filling the cylinder, and allowing it to sink still farther, the closed top is removed, and another section added and secured to the one beneath, when the top is replaced, air is again forced in, and the operation proceeded with as before. It is obvious that the weight of the cylinder must be adequate to resist the upward pressure of the condensed air, or that it must be sufficiently loaded to enable it to do so. When sunk to a sufficient depth it is filled with grouting, concrete, or béton. See AIR-LOCK; CAISSON, where the operations of sinking the piers of the East River Bridge, N. Y., and those of the Mississippi Bridge at St. Louis, are described.

Pneu-mat'ic Pump. An air-exhaust or forcing pump. (See AIR-PUMP.) That illustrated is principally designed for forcing air into oil-wells, etc.

The cylinder *A* is of greater capacity than the cylinder *C*; their respective pistons *b d* are so connected with cranks *c e* on the driving-shaft that while one is ascending the other descends and *vice versa*. Exterior air is drawn into the cylinder *A* through the induction-pipe *j*, and forced through the pipe *a* into *C*, where

Fig. 3851.



Pneumatic Pump.

it undergoes a reduction in bulk proportionate to the lesser capacity of this cylinder, and is forced through the pipe *j* into the well-chamber or other receptacle under a corresponding pressure. When used for forcing liquid from a well, the liquid is caused to pass through the jackets *i l* surrounding the cylinders and connected by the pipe *m*; if air or gas is to be forced into a tank, water is made to circulate through the jackets by the action of the pump *n*, whose piston-rod is also connected with the driving-shaft. See also pages 28–30, Vol. I.

Pneu-mat'ic Rail'way. A railroad whose rolling stock is driven by the compression or exhaustion of air in a tube laid parallel to the track. The plan has a number of variations, which are considered under ATMOSPHERIC RAILWAY.

Medhurst's plan (1810–12), and the one adopted in the Crystal Palace Railway, Sydenham, England, was to run the car on rails laid in the tube, a fringe on the carriage acting as a packing to keep the air from passing the carriage, which thus forms a piston in the tube.

The plan adopted by Pinkus, Clegg, and others, was to have a traveling piston connected by a colter with the carriage, the colter displacing a continuous valve which occupied a slot in the whole length of the pipe's upper surface.

Pilbrow's plan was a traveling piston having a rack on its side operating in succession spur-pinions in bearings on the side of the pipe. The pinion-shafts have other pinions which mesh into racks on the side of the carriage, and impart motion thereto.

Keene and Nichols operated by the expansion of air in elastic tubes against rollers journaled in a pedestal beneath the carriage.

Hallette improved the valve.

Taylor and Condor used magnetic power to connect the traveling piston and the carriage. See ATMOSPHERIC RAILWAY.

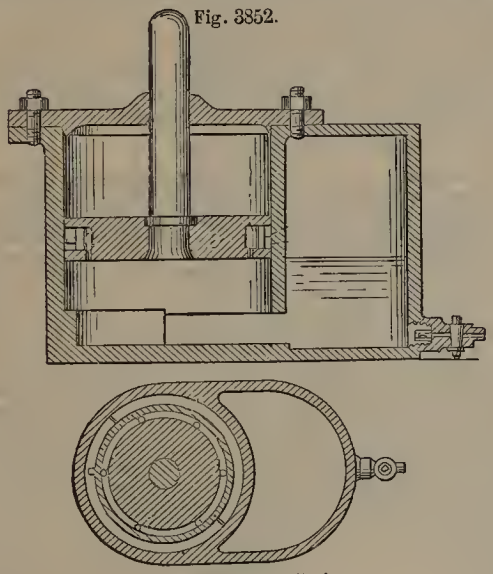
The application of compressed air to driving the machinery of a locomotive does not constitute the line an *Atmospheric Railway* as ordinarily understood. See AIR-ENGINE; AIR-ENGINE, COMPRESSED. See also PNEUMATIC TUBE.

Pneu-mat'ic Spring. *Air confined in bags* and used as a *spring* in *carriages* is specified in the English patent of Walker and Mills, July 3, 1845.

It has been used to receive the recoil of a gun in firing, to arrest the blow of a reciprocating bed in a printing-press, and in many other positions.

Fig. 3852 represents its adaptation to a car-spring. Air is confined in the upper part of the chamber, and acts as a spring when force is applied upon the surface of the water in the

Fig. 3852.

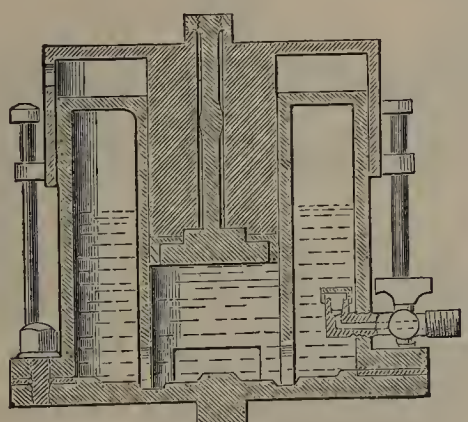


Pneumatic Car-Spring.

other chamber. The water extends below the piston, and enters by openings to the inside of the packing-rings, which are thereby driven against the inside surface of the cylinder.

Fig. 3853 shows a modified form. The plunger reciprocates vertically in the central cylinder, which is surrounded by an annular air-chamber. A liquid is interposed between the cushion of air and the head of the plunger.

Fig. 3853.

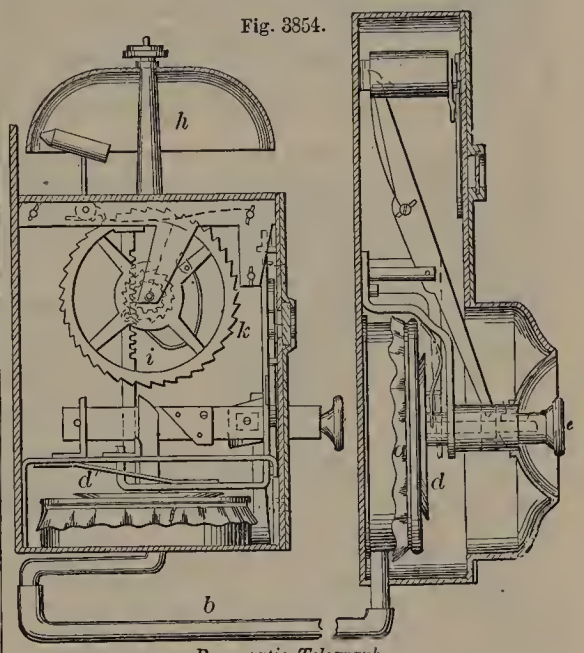


Pneumatic Spring for Cars.

Pneu-mat'ic Tel'e-graph. A telegraph used before the times of Morse and Wheatstone for communicating information by the impulse given to a column of water by pneumatic pressure.

A device in which air instead of water is the transmitting medium was patented in 1868 by Count Sparre of Sweden. The transmitting apparatus consists of a drum covered by an elastic diaphragm *a*, to which an impulse is communicated by a disk *d* at

Fig. 3854.

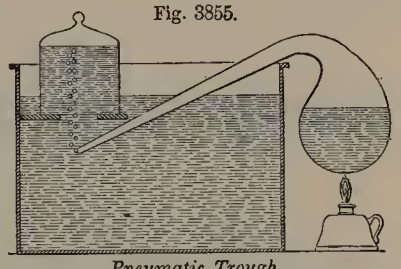


Pneumatic Telegraph.

the inner end of a plunger *e*. The air thus set in motion communicates its vibrations through the tube *b* to a similar elastic covering over the head of a receiving drum, over which is a disk *d'* moving a rack *i* that gears with a pinion on the axis of the ratchet-wheel *k*; the movement of this wheel causes one of its teeth to lift the tail of a pivoted hammer sounding a signal on the bell *h*.

Pneu-mat'ic Trough. The pneumatic trough, with its jars for the collection of gases, is the invention of Hon. Henry Cavendish; it is generally credited to Priestley. The jar, filled with water, rests upon the shelf, and the beak of the retort extends beneath the shelf, so that the gas passing off from the retort passes up into the jar and displaces the water therein.

Fig. 3855.



Pneumatic Trough.

Pneu-mat'ic Tube. To the fertile brain of Dr. Papin of Blois, who lived about the end of the seventeenth century, we are indebted for the first suggestion of conveying parcels in a tube by means of compressed air. This distinguished Frenchman was the first to adopt a piston in the cylinder of a steam-engine. He invented the digester, which is the progenitor of a host of lard-tanks and rendering devices. He was the inventor of the weighted-beam safety-valve. He was the first, so far as we know,

to suggest the use of compressed air conveyed by pipes as a means of transmitting power. See page 26.

After the death of the doctor, the invention took a sleep for a century, which might be a long sleep for anything else, but is for an invention only a reasonable nap. Sixteen or seventeen centuries elapsed between the double-cylinder fire-engine of Ctesibus of Alexandria and the similar engine of Nuremberg. The æolipile of Hero is substantially analogous to the water-wheel of the worthy Dr. Barker, who left us a century back or thereabout, except that the fluid agent of one is *steam* and of the other *water*. The principle is the same, and the turbine invented by Fourneyron, in 1823, does not differ in its principle of action from the æolipile of Hero, 150 B. C., or the reaction water-wheel of Barker, say A. D. 1740.

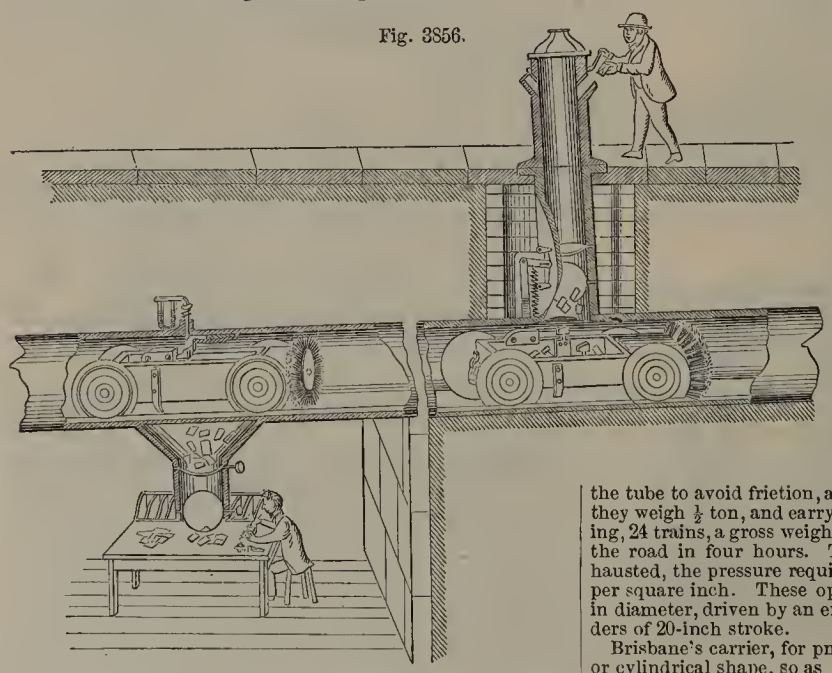
We are much indebted to the worthy Otto Guericke, a magistrate of Magdeburg, for re-inventing the air-pump, about 1650; but Hero, 1,800 years before, had used an air-pump to condense air in a chamber above water to make an artificial fountain. The splendid French edition of Hero's "Spiritalia" was published in Paris during the reign of Louis XIV., — not so very long after the good burgher of Magdeburg had set the ball rolling again. What Archimedes did for the fleet of Marcellus at Syracuse, 212 B. C., Proclus did for the ships of Vitalian at Constantinople some 700 years afterward, and Buffon performs the same feats with burning mirrors in a peaceable way, about the middle of the last century, upon metals, green wood, and various intractable minerals. See page 410.

In 1810, Medhurst took out a patent in England for a means of conveying goods, letters, parcels, and passengers by means of a tube and a blast of compressed air. (*Plenum.*) He proposed to apply it to driving passenger-cars at the rate of fifty miles per hour, the cars taking the shape of the tube.

In 1824, Vallence received an English patent for a substantially similar mode, excepting that the air was exhausted in front of the carriage, and the latter was driven by atmospheric pressure. (*Vacuum.*)

In 1835, Pinkus, an American in England, changed the scheme, the motion of a piston in the tube being transferred to a carriage traveling outside.

Fig. 3856.



Beach's Pneumatic Dispatch.

This takes it out of the domain of our subject, in which the tube is the means of transmission. The subject of farther improvements in the line of the invention of Pinkus is pursued under ATMOSPHERIC RAILWAY.

The pneumatic dispatch-tube was started by a company in London in 1859, for conveying parcels and light goods between the Euston Square Station and the Post-Office in Eversholt Street, London. A continuation to Holborn was opened in 1865.

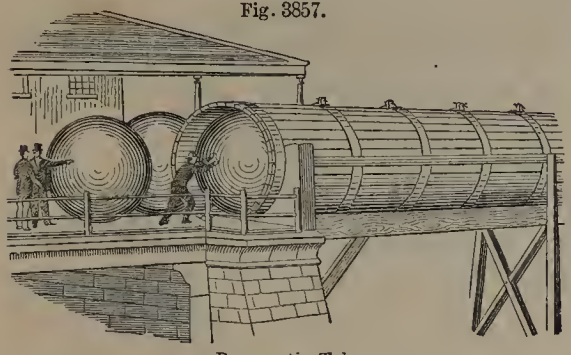
The pneumatic tube for the transmission of passengers or goods has been brought into prominence in the United States by the exertions of A. E. Beach of New York, and passengers were conveyed in an experimental section of tube at the Cooper Institute Exhibition, 1867. Mr. Beach has patented many special appliances having reference to the working of pneumatic tubes, and among the rest one for delivering letters, parcels, etc., November 13, 1866. The pneumatic tube is traversed by a car, which receives and delivers letters at intermediate stations and at the ends of its route. Devices actuated by the car in passing, or controlled by an electro-magnetic apparatus from an office, arrest the car either for the reception of letters from a receiver or their deposition at a given point, as the devices may be arranged or actuated by the electro-magnetic connection. A passenger and freight railway on Beach's plan has been constructed for some distance under Broadway, New York, the intention being to extend it from the Battery to Harlem.

For a number of years past the telegraph-offices of London have communicated with the central office by pneumatic tubes, in which the air is exhausted in front of the carrier and condensed behind it; these tubes are arranged in circuits, so that the current of air is continuous and conveys parcels in each direction at the same time. At each way-station on the line is a receiving apparatus consisting of two short barrels parallel with the main tube, either of which may be put in or out of connection with the line: one of these is open at both ends, so that a carrier may pass through unimpeded, but the other is closed at one end, with the exception of a small opening, so that when it is switched into line with the main tube it intercepts the carrier. The time when a carrier may be expected to arrive is telegraphed to the receiving station. In the telegraph pneumatic dispatch at Liverpool the messages are placed in little round bags, accurately fitting the tube, and urged forward by compressed air under a pressure of eleven pounds to the square inch. The tubes are connected, one with a vacuum chamber and the other with a compressed air-chamber; air being compressed in one and exhausted in the other at the same time by a double-barreled air-pump, operated by an engine working at about one horse-power. A speed of about forty miles an hour is attained.

Within the past few years the pneumatic tube has been applied to some extent for the transportation of passengers and freight as well as letters and parcels. Such is that between Holborn and Euston Square in London. In this the tube at the straight portions consists of iron pipes, cast in 9 feet lengths, 4 feet wide, and 4 feet 6 inches high. The curves vary from 70 to 300 feet radius, and the gradients from 1 in 60 to 1 in 40, some portions of the line being level. The trucks run on rails laid on longitudinal sleepers, and are about 10 feet long; they have an elastic binding at their ends, allowing a small interval between this and the sides of the tube to avoid friction, a perfect vacuum not being required: they weigh $\frac{1}{2}$ ton, and carry a load of $1\frac{1}{2}$ tons; in ordinary working, 24 trains, a gross weight of 240 tons, have been carried over the road in four hours. The air may be either forced or exhausted, the pressure required usually not exceeding $\frac{1}{2}$ pound per square inch. These operations are effected by a fan 22 feet in diameter, driven by an engine having a pair of 24-inch cylinders of 20-inch stroke.

Brisbane's carrier, for pneumatic tubes, is made of spherical or cylindrical shape, so as to rotate when set in motion, avoiding the friction due to the pressure of the weight on bearings.

Fig. 3857.

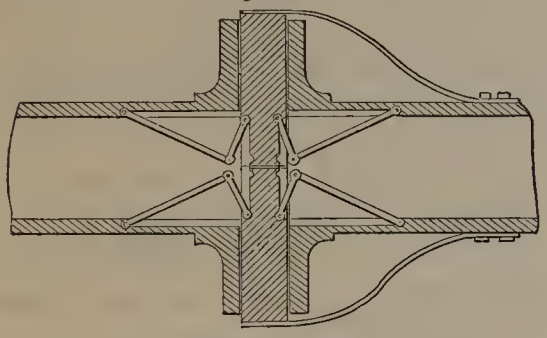


Pneumatic Tube.

Pneu-mat'ic Tube-valve. An interior slide-valve so arranged as to be withdrawn automatically or otherwise when the conveyor or train is to be started, or at passing any particular point.

Beach's valve (Fig. 3858) consists of two parts sliding in vertical guides. The end of a train passing in either direction strikes a pair of toggle-joint

Fig 3858.



Pneumatic Tube-Valve.

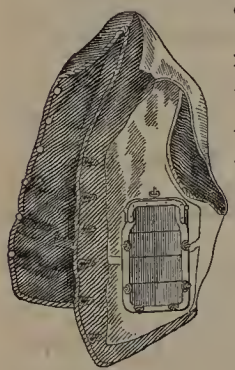
levers which force apart the halves of the valve, which are afterward forced together again by springs exterior to the tube.

Pneu-mat'ic Valve. A valve of the kind employed in an air-pump. A clack-valve of leather or membrane supported and held tense by a metallic ring. Its seat is sometimes greased to insure perfect contact and prevent any air from escaping backward.

Pneu'ma-tom'e-ter; Pneu'mo-nom'e-ter. (*Surgical.*) An instrument for measuring the amount of air exhaled at a single expiration. A *pulmometer*, or *spirometer*.

Pock'et. 1. (*Mining.*) A cavity or hollow in a rock in which grains or nuggets of gold have been intercepted and retained.

Fig. 3859.



Safety-Pocket.

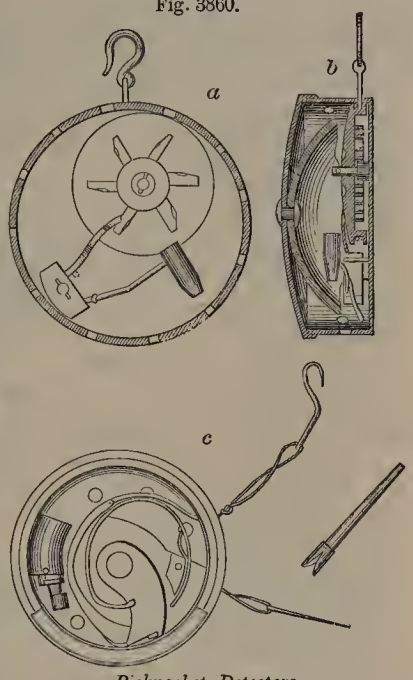
2. A bag at the corner or midlength of one of the longer sides of a billiard-table.

3. (*Apparel.*) A bag inserted in the clothing to contain articles carried upon the person.

Fig. 3859 illustrates a safety-pocket. It is surrounded by a light metallic framing, and its mouth is secured by a device opened or closed by a screw to prevent articles being withdrawn by picking or cutting.

Pock'et-a-larm'. A device worn like a watch and having a chain attached to the hook at its upper end. A pickpocket, in pulling the chain to abstract the supposed watch from the pocket, will turn the spring-wheel whose projections will actuate the hammer and sound the alarm on the bell. *a* is an elevation and *b* is a vertical section of the device.

Fig. 3860.



Pickpocket Detectors.

In *c*, the alarm is attached to any article and also to the pocket. When an attempt is made to abstract the article, the trigger is tripped and the hammer falls upon and explodes the cap. The shell of the device is of such form and size as to be conveniently carried in the pocket. The hammer is capped and cocked by an independent lever, and the working parts do not project beyond the outside shell.

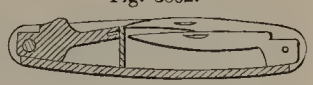
Pock'et-book. A leathern receptacle, divided into compartments for bank-notes, etc., and of shape and size suitable for carriage in the pocket. It has an exterior flap, usually secured by a tongue and loop. See PORTE-MONNAIE.

Pock'et-knife. A knife having one or more pivoted blades, which shut within the handle, and are held firm by the back, which constitutes a spring. The blades are forged on a small anvil with a light hand-hammer by drawing down a rod of steel and cutting off sufficient to form the blade and joint. In making the latter a second heat is taken, and the finish is completed at a third heat; they are then hardened by plunging while red-hot in cold water, and tempered by laying them side by side on an iron plate over the fire, where they remain until their surfaces assume a purple or brown color.

Fig. 3861.

Knife with Detachable Blades.

Fig. 3862.



Knife with Watch-Key.

Fig. 3861 is a knife in which the shank of the blade is so slotted that it can be readily slipped on or off the customary pivot in the handle. A lever device is used to retract the spring when the blade is to be inserted or removed.

Fig. 3862 has a watch-key in place of one of the blades.

Pod-bit. A boring-tool adapted to be used in a brace. It has a semicylindrical form, a hollow barrel, and at its end is a cutting lip which projects in advance of the barrel. See BIT.

Poil. (*Fabric.*) *Feather shag.* A kind of velvet with long pile.

Point. 1. (*Bricklaying.*) To fill the joints of

masonry, brickwork, tiling, slating, etc., with mortar, pressed in by the point of the trowel.

When the mortar of a brick building, by exposure to the air, has become rotten or has fallen out at the surface of the joints, the space is *pointed* or filled with mortar, pressed in, and made flush with the surface of the bricks.

When the joint receives a line of white paint to make it more conspicuous, it is said to be *penciled*.

Filling up the joint with fresh mortar, leaving it flush, is *flat-joint pointing*. If plaster be inserted in the joints with a regular projection, and neatly pared to a parallel breadth, it is called *tuck-pointing* or *tuck-joint pointing*.

2. (*Masonry.*) *a*. The stone-mason's punch, used in the reduction of the face of the stone, leaving it in narrow ridges, which are dressed down by the *inch-tool*. See STONE-WORKERS' TOOLS.

b. A pointed chisel for nigging ashlar.

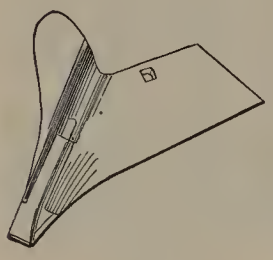
3. (*Nautical.*) *a*. One of the 32 divisions into which the circumference of the horizon and the mariner's compass are divided, each comprehending 11° 15′. See MARINER'S COMPASS.

b. A flat piece of braided cordage attached to the reef-band of a sail to tie up a reef. See REEF-POINT.

c. To prepare the end of a rope so that it may reeve through a block and not unlay. A few yarns are taken out and a mat worked over it by its own yarn.

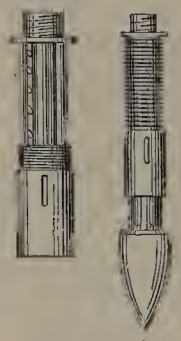
d. To brace a yard so as to bring it end on to the wind.

Fig. 3863.



Plow-Point.

Fig. 3864



Drive-Well Point.

4. (*Plow.*) The extreme forward end of the *share* as distinguished from the *wing*.

5. A railway switch.

6. The lower end of a driven-well tube.

7. (*Bookbinding.*) A register mark made by the printer in aligning his sheet on the tympan and forming a guide to the folder.

8. (*Engraving.*) The etching-needle of an engraver.

9. A fragment of diamond containing a natural angle adapted for glass-cutters' uses. Fragments which are to be made into powder for the lapidary are called *bort*.

10. (*Knitting-machine.*) Beardless needles; also known as SHIFTERS (which see).

11. Lace wrought by the needle.

12. (*Machinery.*) Position in relation to power or accessory portions; as, —

The *dead point* of a crank.

The *fixed point* on which a body moves.

The *point of suspension* of a balance, etc.

13. (*Perspective.*) That part on the drawing sheet to which lines converge; as, the *accidental* or *vanishing point*, the *point of distance*, the *point of sight*.

14. (*Physics.*) *a*. A line of demarcation or limit; as, —

The *boiling* point of a liquid.

The *melting* point of a solid. See FUSING-POINT.

The *evaporating* point, as of water.

b. Said also of instruments; as, —

The *freezing* point of a thermometer.

The *dew* point on a hygrometer, etc.

15. (*Turning.*) A lathe center.

16. (*Printing.*) One of the pins placed on the tympan or feed-board of a printing-press, to perforate the sheet at the time of the first printing to secure a *register* when the sheet is turned.

The points are generally covered by a perforated spring plate at the first feeding, and the sheet fed by a guide. After the sheet is punctured, it is *laid on* so that the points pass through the same holes.

Perfecting-presses sometimes use points to perforate the printed sheets, and the point-holes serve as guides for feeding to a folding-machine.

Campbell's single-cylinder book-press is provided with electric points, and the electric circuit must be completed by bringing the perforations over the needles before the feeding can go on.

17. (*Harness.*) A short strap stitched to a wide one for the purpose of attaching the latter to another strap by a buckle. The end of any strap that is provided with holes for the buckle-tongue.

18. (*Fortification.*) The junction of certain lines of defense, as the *point of the bastion*, the salient angle formed by its meeting faces; the point of intersection of the curtain and the flank; the point at the shoulder of the bastion, etc.

19. (*Ordnance.*) To lay a gun, including the direction and elevation.

Point'al. 1. (*Carpentry.*) A king-post.

2. (*Masonry.*) A pavement of diamond-shaped slabs.

Point-blank. (*Gunnery.*) *a*. A shot discharged in a horizontal direction.

b. A gun horizontally leveled.

Point-blank range is the extent of apparent right-line of a ball horizontally discharged.

Point'ed Arch. (*Architecture.*) One struck from two centers and meeting above, forming a lancet shape. It is a feature of the Gothic order of architecture. See ARCH.

Point'er. 1. (*Stone-working.*) A stone-mason's chisel with a sharp point, used in spawling off the face of a stone in the rough.

2. (*Bricklaying.*) A tool for clearing out to a given depth the old mortar between the courses of bricks in a wall, to be replaced by a fresh body of mortar.

3. (*Railway.*) The adjusting lever of a switch.

4. The index finger or hand of a dial or scale.

5. A graduated circle with one fixed and two adjustable radial legs. By placing them at two adjoining angles taken by a sextant between three known objects, the position of the observer is fixed on the chart.

Point-hole. (*Printing.*) A hole made in a sheet of paper by a register-pin or by points on the tympan.

Point'ing. (*Bricklaying.*) The finishing or renewing a mortar-joint in a wall.

Flat-joint pointing consists in filling the joint even and marking it with a trowel.

Tuck-joint pointing. The joints are finished with fine mortar pared to a parallel edge and slightly projecting.

Point'ing-ma-chine'. One for pointing rails, pickets, matches, etc., as the case may be.

Point'ing-rods. Rods used in the exercise of guns and mortars.

Point'ing-wire. An iron wire with a loop at

one end, used for sighting mortars by, when the proper line of fire has once been found.

Point-pa'per. Pricked paper for making, copying, or transferring designs.

Fig. 3865. **Poin'trel.** A graving-tool.

Point-Tool.

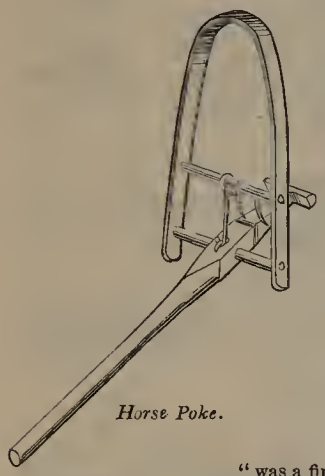
Point-tool. (*Turning.*) One ground off to a sharp point at the midwidth of the end of the blade.

Poi'tral. (*Harness.*) A breast leather for saddles or for draft.

Poke. A device to be attached to a breechy animal to prevent its jumping over, crawling through, or breaking down fences. As David says, "that there be no breaking in nor going out." They vary with the kind of stock to which they are attached, — horses, cattle, hogs, or geese. They are sometimes called yokes; as, for instance, goose-yoke. It is more convenient, however, to class them as pokes, the term "yoke" being applied to the device by which animals draw their loads, for which see YOKE.

In Ohio, a fence which is pig-tight, horse-high, and bull-strong is said to be a thoroughly good fence.

Fig. 3866.



Horse Poke.

Fig. 3866 is a poke for horses. The bar is pivoted to the bow, and inclining forward serves ordinarily to cover the points, but when brought in contact with a fence the points are unmasked to pierce the animal.

Po'ker. 1. A metal used in hooping masts.

2. A stoking-bar.

Po-lac'ca. (*Nautical.*) A vessel with three masts used in the Mediterranean. Beppo's ship

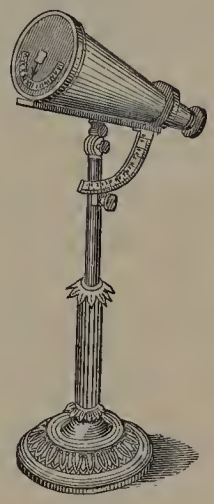
"was a fine polacca,
Manned with twelve hands and laden with tobacco."

Po'lar Cir'cle. Two small circles on a globe, 23° 28′ from the poles and parallel with the equator, — the arctic or north polar circle, the antarctic or south polar circle.

Po'lar Clock. An optical instrument invented by Wheatstone, for ascertaining the time of day by means of polarized light. A glass disk is fixed within a ring at the extremity of a vertical pillar, and so inclined that its plane is perpendicular to the earth's axis. The lower half of the disk is graduated, with the hours from 6 to 6. Within the ring the broad end of a conical tube is fitted so that it may turn freely, and is closed by another glass disk which carries centrally a star or other figure composed of thin films of selenite, exhibiting strongly contrasted colors under exposure to polarized light; and an index is painted in the prolongation of one of the principal sections of the selenite films. At the smaller end of the tube is a Nicol prism, having its diagonals at angles of 45° with the principal sections of the selenite.

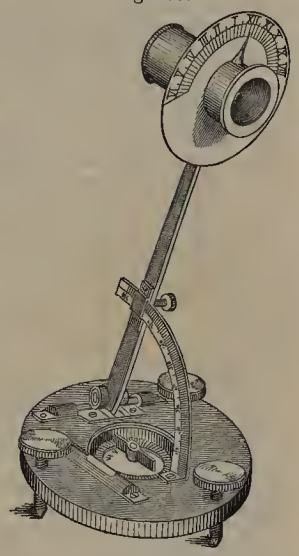
The axis of the conical tube is adjusted in line with the earth's axis. On looking through the prism, the selenite star will appear colored, except in two positions. In one of these a circular disk in the center of the star will appear of a certain color, as red, and in the other it will exhibit the complementary color. This is caused by its axis being placed at an angle of 22½° with the other films of selenite composing the star. The tube is turned until the star shows no color, the central disk then appearing red. The index will then point to the hour.

Fig. 3867.



Wheatstone's Polar Clock.

Fig. 3868.



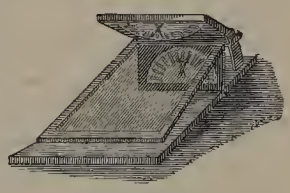
Polar Clock.

The principle of the clock consists in the fact that the light scattered from the minute particles of the atmosphere is polarized, and this effect is best marked when the reflected light is examined at right angles to the course of the original light; all the changes of color resulting from the operation of the instrument as above described show the position of the sun, or, in other words, give the time of day.

Fig. 3868 is a portable form of this instrument, adapted for adjustment to any latitude.

Fig. 3869 is a simpler though less accurate form, in which twenty-five films of selenite are arranged equidistantly and radially in a semicircle upon a plate of glass fixed in a frame in a plane inclined to the horizon at an angle equal to the complement of the polar elevation, and adjusted perpendicularly to the earth's axis. The light passing through this plate falls upon a reflector of black glass adjusted at an angle of 56° 45′ with the plate, and is polarized. The hours are denoted by figures at the ends of the radial films of selenite; these will at all times appear of various shades of two complementary colors; that plate which exhibits most vividly a particular color, as red, indicates the hour.

Fig. 3869.



Polar Clock.

Po'lar Di'al. A dial having a plane parallel to the axis of the earth and perpendicular to the meridian of the place. The style or gnomon is parallel to the plane of the dial, and the hour lines are parallel straight lines, whose distances from the meridional line are respectively proportioned to the tangents of the angles which the hour-planes make with the plane of the meridian.

The *common dial* becomes a polar dial at the equator.

Po-lar'i-scope. An instrument for observing

the phenomena exhibited by polarized rays of light proceeding from a luminous object, as the sun. The principle upon which its action depends is thus explained by Professor Airy: —

"Common light consists of undulations in which the vibrations of each particle are in the plane perpendicular to the wave's motion. The polarization of light is the resolution of each vibration into two, one passing through the direction of the wave's motion, and the other perpendicular to that plane, which become in some instances the origin of waves that travel in different directions. When we are able to separate one of these from the other, we say that the light of each is polarized." When the resolved vibration parallel to the plane is preserved unaltered, and that perpendicular to the plane is diminished in a given ratio (or *vice versa*) and not separated from it, we say that the light is partially polarized."

Light may be polarized by reflection at a proper angle from the surfaces of transparent media; by transmission through crystals possessing the property of double refraction; and by transmission through a sufficient number of unerystallized transparent plates placed at proper angles.

If two plates of glass be placed at the open ends of two tubes turning one within the other, the plates being fixed at an angle of 33° with the axes of the tubes and revolved, it will be found that when the two plates are parallel to each other the amount of light reflected from one to the other and transmitted to the eye will be at a maximum, and when they are at right angles to this no light at all will be reflected. It thus appears that a ray reflected from the surface of glass at this angle cannot be again reflected from a similar inclined surface; this is expressed by saying that the light is polarized in the plane of reflection.

When a reflected ray is received upon a tourmaline plate the whole of the light will be transmitted, if its axis, that is, the axis of the crystal from which it was cut, be parallel to the reflecting surface; on revolving the plate the amount of light transmitted will diminish until its surface is at right angles with that of the reflector, when it will entirely disappear. Light is only completely polarized by reflection, when it strikes the reflecting substance at a particular angle; this varies in different substances, being in the case of glass 33°, the complement of which, 57°, is called the angle of polarization. Sir David Brewster, from numerous experiments, deduced the following law: "The tangent of the polarizing angle for any medium is the index of refraction for that medium."

The phenomenon of double refraction, exhibited by Iceland spar (crystallized carbonate of lime), is a familiar one.

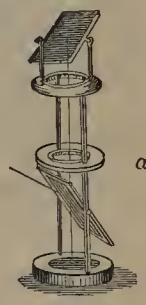
If any small object be placed in contact with a piece of this spar and viewed through it, two images, separated by a slight interval, will appear, and by turning the piece round, the same surface still resting on the object, these images will be caused to revolve around each other. By sawing the piece in two in the proper direction and cementing the two surfaces with Canada balsam, one of these images may be entirely got rid of. A piece thus treated constitutes Nicol's prism, and forms the means by which a very large proportion of the observations on polarized light are made. A device of this kind is furnished with all the better class of microscopes. Tourmaline and various other minerals also possess this property in a greater or less degree. The two pencils of light formed by double refraction are found to be polarized in planes at right angles to each other, exhibiting the same phenomena as light polarized by reflection. The images may be received on a reflecting surface at the proper polarizing angle, viewed through a plate of tourmaline, or through a second crystal having the power of double refraction. In the latter case it is found that when the homologous faces of the two crystals are parallel, neither of the pencils formed by the first will be separated by the second crystal, but on turning the latter round, each pencil is separated into two, forming four images; the two which succeed those originally seen appear faint, but when the axes of the crystals are at an angle of 45° with each other, will be equally bright with the first; the first gradually diminish in brightness as the angle approaches 90°, and the four increase their proximity until at 90° they coincide, forming but two images as before, the relative positions of which are, however, reversed from those they occupied at the beginning; that which was above now appearing below, and *vice versa*. These phenomena were first observed by Huyghens. Circular polarization is produced when light is twice totally reflected from the second surface of bodies at their angle of maximum polarization; it may also be produced by the passage of light through rock crystal, as was discovered by Arago, or through some fluids, as oil of turpentine or solution of sugar, as was ascertained by Biot and Seebeck.

Elliptic polarization is produced by reflection from the polished surfaces of metals at angles between 70° 45′ and 78° 30′, gold having the least and tin the greatest polarizing angle. This property was discovered by Sir David Brewster.

"When Huyghens was occupied with the double refraction of light in crystals of Iceland spar, *i. e.* with the separation of the pencils of light into two parts, he also discovered, in 1678, that kind of polarization of light which bears his name. More than a century elapsed before the discovery of this isolated phenomenon was followed by the discoveries of Malus, Arago, Fresnel, Brewster, and Biot. Malus, in 1808, discovered polarization by reflection from polished surfaces; and Arago, in 1811, discovered colored polarization. A world of wonders of variously modified waves of light gifted with new properties was now opened. A ray of light which reaches our eyes from the regions of space, from a heavenly body many millions of miles distant, when received in Arago's polariscope, tells, as it were of itself, whether it is reflected or refracted, whether it emanates from a solid, a fluid, or a gaseous body, and even announces its degree of intensity. Pursuing this path, which takes us back through Huyghens to the seventeenth century, we are instructed respecting the constitution of the solar orb and its envelopes, the reflected or the proper lights of the tails of comets, and of the zodiacal light, the optical properties of our atmosphere, and the position of the four neutral points of polarization, which Arago, Babinet, and Brewster discovered. Thus man makes for himself as it were new organs which, when skillfully used, open to him new views of nature." — HUMBOLDT.

Various devices for inducing and observing the phenomena of polarization have been contrived.

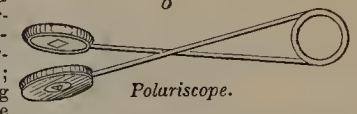
Fig. 3870.



In Fig 3870 *a* illustrates Norremberg's polariscope, for use with the magic-lantern. Two mirrors are arranged at an angle of 35° from the vertical, and the object placed on the stage between them; on revolving the upper mirror the field of vision appears clear at 0° and 180°, and dark at 90° and 270°.

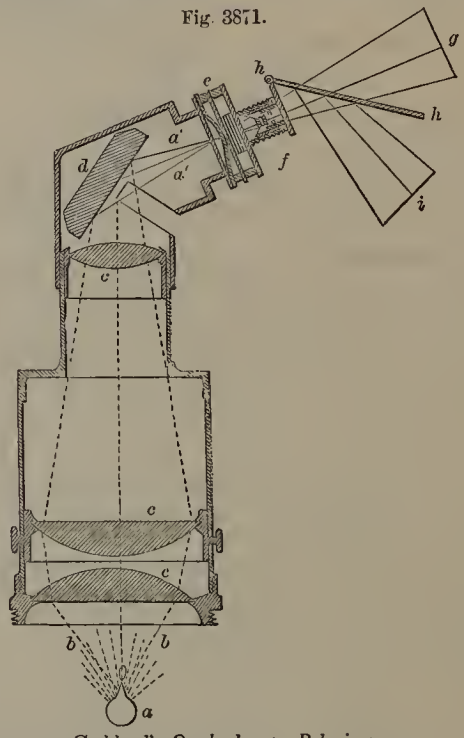
b is the tourmaline polariscope: two plates of tourmaline are inserted in the jaws of a forceps-like wire. By inclosing an object between them and imparting a rotary motion, colored rings are exhibited.

Fig. 3871 represents Goddard's oxyhydrogen polariscope. *a* is a ball of lime exposed to the ignited jet from the compound blowpipe; *b b*, its rays refracted by the condensing-leuses *c c c*, and falling upon the mirror *d*, composed of ten plates of thin flattened crown-glass and placed within the elbow of a tube bent to the polarizing angle of crown-glass. *a′ a′*, the polarized rays after reflection; *e*, a double refracting crystal (selenite) in the focus of the object-glass *f*, which forms an image of the crystal upon a screen at *g*; an analyzing plate *h* composed of sixteen plates of mica being caused to turn upon its axis, the image of the selenite upon the disk is caused to exhibit alternately the primary and secondary colors at the same time, one being reflected in the direction *i*, and the other thrown upon the screen at *g*.



Polariscope.

Fig. 3871.



Goddard's Oxyhydrogen Polariscope.

Po'lar-is-tro-bom'e-ter. The title given to an instrument devised by Professor Wilde of Berne for investigating the relations of various liquids to polarized light.

Po-lar'i-ty. The property of attraction or repulsion, or of taking certain directions.

Po'lar-iz'er. The lower prism. The one beneath the stage of the microscope in polarizing apparatus.

Pol'da-ry. (*Fabric.*) A kind of coarse canvas. *Poldway.*

Pold'way. (*Fabric.*) Coarse bagging stuff for coal-sacks, etc.

Pole. 1. The tongue of a vehicle.

The *pole* was the universal appendage to the ancient vehicle. The animals, of whatever kind, were attached to the vehicle by yokes. See YOKE; CHARIOT.

Chariots with two or three poles were used by the Lydians. Here we perhaps see the first shafts, unless the bilateral poles of the Scythian nomad, fastened to a surcingle and dragging behind the animal, may be so considered.

2. (*Nautical.*) *a.* A mooring-pole.

b. A setting-pole.

3. (*Galvanic Batteries.*) *a.* The poles are the ends of the wires or the terminal points of the connections which proceed from the battery, and convey *positive* and *negative* electricity (so called) respectively. As the course of the current is from the positive metal to the liquid, and thence to the negative metal, proceeding from the latter by the circuit wire to the positive metal, whence it started, so the wire from the copper conveys positive electricity and is the *anode*, while the zinc is the *cathode*.

The north end of a magnetic needle.

Pole-axe. Originally, an axe on a pole or long handle. The *poll* of an axe is the head. The pole-axe (*b*) now used by butchers in felling bullocks and

Fig. 3872.

Pole-Axes, etc.

hogs has a handle of ordinary length, and is used to deaden the animal by a blow on its *poll*, but the name is not thence.

As a long-handled axe it was used as a weapon in the Middle Ages.

In the navy it is a heavy hatchet (*a*) having a handle 15 inches long and a sharp point turning downward on the side opposite the blade. It is used for boarding, resisting boarders, cutting ropes or nettings, etc.

c c are pole-axes of the time of Charlemagne. The handles are shown as broken short off. *d* is a battle-axe of medieval times.

Pole-car'riage. A carriage furnished with a *pole* or *tongue*, in contradistinction to one with *shafts* or *thills*.

Pole-chain. (*Vehicle.*) The chain on the fore end of a carriage-pole, leading to the collar or the breast-chains of the harness.

Pole-crab. (*Vehicle.*) A double loop (*i*, Fig. 3872) on the fore end of a carriage-pole, to receive the breast-straps of the harness.

Pole-foot. (*Vehicle.*) The hind end of a pole which goes into the cleaves of the futchels.

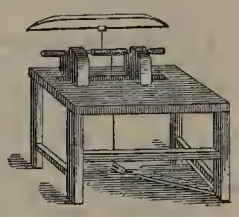
Pole-futch'el. (*Vehicle.*) The jaws between which the hinder end of a carriage-tongue is inserted.

Pole-hook. 1. The hook on the end of a carriage-tongue.

2. A boat-hook.

Pole-lathe. A lathe in which the work is supported between centers on posts rising from the bed, turned by a strap which passes two or three times round the work. The lower end of the strap is connected to the treadle, and the other end to a spring-bar on the ceiling. One of the centers is an iron pin, and the other is on a screw in the other standard. The rest is a rail or bar extending from one puppet to the other. The work is intermittent, the chisel cutting as the treadle descends; the pressure of the foot being relaxed, the spring-bar raises the treadle, running the work in the other direction. See LATHE.

Fig. 3873.



Pole-Lathe.

Pole-mast. (*Nautical.*) A mast made with a single pole, in contradistinction to a mast built up, and secured by bands.

Pol'e-mit. (*Fabric.*) A French camlet.

Po-lem'o-scope. A glass with a mirror at an angle of 45°, designed to enable a person to view objects not directly before the eye. Invented by Helvetius.

It is used in opera-glasses to view persons obliquely without apparently directing the glass at them.

It is also used for viewing objects beyond an obstructing wall or bank, as in the interior of a fortress. See ALTISCOPE.

Pole-pad. A pad of leather stuffed with wool and distended by an interior frame of iron, slipped and keyed on the end of the pole of a gun-carriage, to prevent injury to the horses.

Pole-plate. (*Carpentry.*) The plate of a frame which supports the heels of the rafters. A *wall-plate.*

Pole-prop. A bar for supporting the end of the pole or tongue, especially used with the various carriages of the artillery service.

Pole-pro-pel'ler. A mode of propulsion of boats in which the ends of poles are pushed against the bottom of the river to propel the boat.

Pole-strap. A heavy strap by which the pole of the carriage is attached to the collar of the horse. Also called *pole-piece.*

Pole-tip. A tubular iron at the front end of a wagon-pole. See *j*, Fig. 3872.

Po-lim'i-ta. (*Fabric.*) A variegated stuff.

Pol'ing. 1. (*Glass-making.*) An operation for ridding glass of a lilac color due to an excess of manganese. The molten glass is stirred with a pole, which introduction of a carbonaceous element changes the sesquioxide into a protoxide, and the color disappears.

2. (*Copper-manufacture.*) An operation to cause an ebullition in molten copper to accelerate the effect of the supernatant charcoal. The green pole yields its juices in a gaseous form, which causes the fluid metal to bubble.

Pol'ings. Boards supporting the side-earth in excavating tunnels.

Pol'ished Brick. Bricks which are rubbed upon

a bench plated with iron, to make their surfaces perfectly even. This process is only gone through with the very best bricks, and its cost is such that it is not employed to any very great extent.

Pol'ish-ing. The different kinds of polishing-wheels have distinguishing names, according to their material.

Polishing-wheels are usually leather covered.

Lapping-wheels have *metallic* rims.

Glazers are of wood.

Buffers are of leather.

Each has a powder or paste of a fineness adapted to its work. The *buffer* is a finisher, and usually has *rouge*.

Pol'ish-ing-block. *a.* A block between the jaws of a vise on which an object is laid to polish it by an emery strip or otherwise.

b. A block shod with polishing material and moved over the face of the object to be polished.

Pol'ish-ing-cask. 1. A rolling barrel in which articles are placed to polish by mutual attrition or by grinding against some polishing-powder placed in the barrel with them.

2. A barrel in which grained gunpowder is placed with a small quantity of graphite, which gives it a polish.

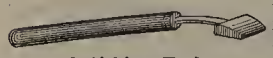
Pol'ish-ing-file. A smooth file. A burnisher.

Pol'ish-ing Glass. Plate-glass is polished after grinding by means of rubbers set in a frame which is caused to traverse back and forth over the plate. See PLATE-GLASS.

Pol'ish-ing-ham'mer. A hammer for finc-dressing the surfaces of plates.

Pol'ish-ing-i'ron. (*Bookbinding.*) An implement for finishing the covers of books. It is heated and passed over the leather, the lining paper, and such other parts as require smoothing and polishing. They are made of various shapes and sizes.

Fig. 3874.



Polishing-Tool.

Pol'ish-ing-ma-chine'. 1. A machine in which rice, deprived of its hull, receives a farther trituration to deprive it of its red skin or cuticle. A *whitening-machine.*

2. (*Cotton.*) A machine which brushes the surface of sized yarn, or burnishes sized thread.

Pol'ish-ing-ma-te'ri-als. These are derived from various sources, principally from the mineral kingdom, though vegetable substances and the skins of animals and fish are used for particular purposes, as is also the interior shell of the cuttle-fish. Pure carbon in the diamond is the hardest substance known in nature, and is much employed in the form of powder for cutting and polishing gems. As charcoal, carbon is also used for polishing copper and other soft metals.

Alumina, when pure and crystalline, as in the ruby, sapphire, etc., is next in hardness to the diamond. In combination with a small proportion of silex and iron, it composes the principal part of corundum, emery, and rotten-stone, which are largely employed in grinding and polishing the harder metals, minerals, and glass.

Some clays and loams of which alumina constitutes a large part are also used for like purposes.

Silex in its various forms, as quartz, sand, etc., and mixed with alumina and other mineral substances constituting grits or grindstones, hones and slates, pumice-stone, and some others, are used for abrading and polishing. Tripoli and rotten-stone are employed in polishing the surfaces of metals and other substances. The oxide of iron, called crocus and rouge, and the oxides of tin and lead, known as *putty-powders*, are extensively used in the arts for producing very smooth surfaces. These are prepared artificially. Lime and chalk are also employed in some polishing processes.

Pol'ish-ing-mill. A lap of *tin* or of wood coated with *list* or *leather*, used for the finishing processes of the lapidary. See LAPIDARY'S MILL.

Pol'ish-ing Nee'dles. The polishing of needles is effected by treating from 40,000 to 50,000 at a time.

The needles are arranged in heaps upon a piece of canvas, the needles in each heap lying parallel, without regard, however, to heads or points. Emery, oil, and soft soap are sprinkled over the heaps, after which they are rolled up in the canvas and bound by a coil of twine, making a bundle three or four inches thick and two or three feet long. A number of such rolls are laid on a table with raised edges, a weighted and reciprocating slab resting upon them, so as to roll the bundles back and forth, causing the needles to roll and rub against each other, removing the scale, and eventually scouring and polishing each other.

The rubbers work at the rate of 20 or 30 movements in a minute, and the process is carried on from 48 hours to 8 days, according to the quality. The rubbing is suspended every 8 hours, to renew the canvas, which becomes worn out, to wash the needles, and to add fresh emery, putty-powder, oil, etc., as the case may require, the abrading material being applied of a gradually increasing fineness.

Pol'ish-ing-pow'der. Diamond, sapphire, ruby, corundum, emery, rotten-stone, flint, tripoli, pumice-stone, oxide of iron, oxide of tin, and chalk are all employed in a pulverized state for polishing. The first three are used by the lapidary; corundum and emery principally by metal-workers. They, as well as oxide of iron (crocus, rouge) and oxide of tin, are also, however, employed for polishing glass. Pumice is more commonly used on wood-work, while tripoli and chalk, under the form of whiting, are particularly employed for domestic purposes, in cleaning brasses, window-glass, etc.

Pulverized graphite, either alone or in combination, is also largely used in domestic economy for polishing stoves, etc.

Pol'ish-ing-slate. A hone. Schist.

Pol'ish-ing-snake. A lithographer's tool.

Pol'ish-ing-tin. A bookbinder's tool.

Pol'ish-ing-wheel. A wooden wheel covered with leather and charged with crocus, rouge, putty-powder, etc. It is used in polishing metallic articles of relatively small size which are presented to it. A coarser grade of powder, such as emery or tripoli, constitutes a *grinding-wheel* or *glazer*.

A polishing-wheel prepared from a leather dressed with oil, like chamois and buckskin, is called a *buff-wheel*. The soft and fluffy surface is charged with polishing-powder.

The cutler's polishing-wheel has a wooden center, is covered with leather, and charged with crocus, used dry. It has a speed of 70 to 80 feet per second. The development of heat by friction improves the polish, and the blade is moved to and fro, from end to end, by a quick motion. Skill and practice, it is almost needless to observe, are necessary in this as in all other manipulations. The hand is protected from the heat by a piece of felt.

Polishing-wheels for small steel instruments are made as follows: —

Take a piece of sole-leather of a size suitable for the desired wheel, make a hole through the center, slip it on the mandrel of the lathe; turn it down to the size desired; coat the face of it with glue, and apply as much coarse emery as the glue can be made to take; put it aside to dry. Make another in the

same way, only using flour of emery instead of the coarse. Form a third wheel in the same manner, but instead of the glue and emery, apply crocus with water. The wheels may be of any size, by fastening several thicknesses together with common shoe-pegs.

A wheel for carrying the pumice, in polishing vulcanite, can be formed by fastening together two of these leather wheels with brass screws, between which are three or four thicknesses of woolen cloth cut somewhat larger than the leathers.

Poll. 1. The blunt end of a hammer. The *head* of a hammer, the smaller end, is the *peen*, whether an edge or a point.

2. The *butt* of an axe or hatchet as distinguished from the *bit*, which is the cutting blade. See Fig. 3872, *e poll*, *f bit*, *g eye*.

Not to be confounded with *pole*-axe, which has a halberd, or axe on a pole.

One form of tool may be a *poll*-axe which has a stud on the poll for felling beeves and hogs.

Poll-adze. An adze with a striking face on the *head* (*poll*) opposite to the *bit*. See *h*, Fig. 3872.

Poll-pick. (*Mining.*) A pick on the end of a pole so as to be worked by blows endwise, like a crow-bar.

Pol'roz. (*Mining.*) The pit underneath a water-wheel.

Pol'ver-ine. Glass-makers' ashes.

Pol'y-chord. (*Music.*) An octave-coupler.

Pol'y-chrome. A picture executed in various colors. Anciently applied to a statue colored to imitate nature. Some of the remains of Grecian sculpture yet exhibit traces of the color upon them.

Pol'y-gon. (*Fortification.*) The *exterior* polygon is the figure formed by lines connecting the angles of the bastions round the work.

The *interior* polygon, a figure formed by lines connecting the centers of the bastions all round.

Pol'y-graph. 1. An instrument for making a number of drawings or writings simultaneously. It is on the principle of the pantograph, and was invented by Hawkins (English).

A number of pencils are placed in a framework of jointed rods, so arranged that each subordinate one partakes of the motion of the principal one, which is guided by the writer or draftsman.

2. A manifold writer or a copying-machine.

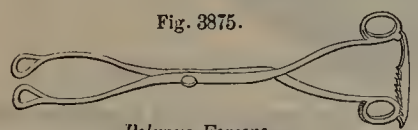
Pol-ym'e-ter. An instrument for measuring angles.

Pol'y-op'tron. A lens, one side of which is plane and the other convex, with a number of concave facets. The effect is to give a number of diminished images. It is a toy.

Pol'y-pan'to-graph. An instrument on the principle of the pantograph, by which a number of similar designs may be simultaneously executed upon a metallic plate or roller from a single pattern. Invented by M. Gavard, Paris.

Pol'y-pus-for'ceps. A ring-handled forceps, from 4 to 7 inches in length, of various curves, slender blades, grooved and deeply serrated margins.

Fig. 3875.



Polypus Forceps.

It is used for extracting tumors and polypi, taking hold of them by their pedicles and twisting them until they come off. The cut represents one of a larger kind used for uterine polypi.

Pol'y-scope. A multiplying lens. A plano-convex lens whose protuberant face is cut into numerous facets, each of which gives an image of the object viewed.

Pol'y-zo'nal Lens. A burning-lens constructed of segmental lenses arranged in zones.

In the illustration, the lens is shown with a central piece surrounded by four segments which are encircled by eight segments.

Fig. 3876.

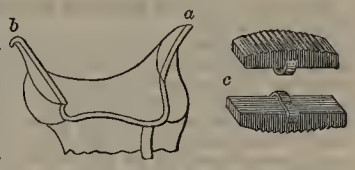
Polyzonal Lens.

The object is to obtain lenses of large size for lighthouses, free from defects, and having but slight spherical aberration. Buffon first suggested the idea. Brewster made them. See BURNING-GLASS; BURNING-MIRROR, pages 410, 411; MIRROR, page 1452.

Pom'el. A boss or knob on the summit of a turret roof.

Pom'mel. 1. (*Saddlery.*) A knob on the front part of a saddle. The seat of a saddle is between the *pommel a* and the *cantle b*. In the Murdoch saddle the seat is suspended between the *pommel* and *cantle*, which are united by spring-bars called *side-plates*. In the *Spanish* saddle the *pommel* and *cantle* are high, so that the rider sits in a deep seat. In the *half Spanish* the parts named are less elevated. In the *English* and *Somerset* trees, still less so. A high pommel is sometimes called the *horn*.

Fig. 3877.



Pommel and Cantle.

2. (*Currying.*) A block of hard wood *c* used by curriers in pressing and working skins to render them supple. It is flat above and rounded below, the lower surface having transverse, parallel straight grooves. It is also used in *graining* and *boarding* leather, and is otherwise known as a *crippler*.

3. A knob on the hilt of a sword.

4. The butt-end of the stock of a fire-arm.

5. The knob on the cascabel of a cannon.

Pom-mel'ion. The knob on the cascabel of a gun.

Pom'pet. A printer's inking-ball.

Pond. (*Hydraulic Engineering.*) A *reach* or *level* of a canal. Two ponds of varying levels are connected by a *lock*.

Pon-gee'. (*Fabric.*) A coarse silk goods.

Pon'iard. A dagger.

Pon'til; Pon'ty; Pon'tee. The iron rod used by a glass-blower to support the glass while working.

The blowing-rod is the tube on which the mass of glass is withdrawn from the pot and blown into shape.

Pon-ton'. 1. (*Military Engineering.*) A bateau of wood or metal, or a light framework covered with water-proof material, used as a float for supporting a temporary bridge. *Pontoon.*

In the United States Engineer Service they are made of wood. Corrugated metal and rubber have also been employed.

The British service employs either Colonel Blanchard's or Colonel Pasley's pontons. The former are cylindrical and are made of tin-plate; they have hemispherical ends, and are divided into compartments by longitudinal and transverse partitions, which serve as braces.

Pasley's consist of a light timber frame covered with copper; they are transversely divided into two halves, which are united by lashings for use and separated for transportation. Each half is also divided into compartments. The whole forms a decked canoe adapted for rowing. See PONTON-BRIDGE.

2. (*Nautical.*) *a.* A barge or lighter of large capacity, used in careening ships, raising weights,

drawing piles, etc., or capable, in pairs, of acting as *camels*. See CAMEL.

b. A barge or flat-bottomed vessel furnished with cranes, capstans, and hoisting tackle, used in wrecking, in connection with a diving-bell, or in raising submerged vessels.

3. (*Hydraulic Engineering.*) *a*. A water-tight structure or frame covered with water-resisting material placed beneath a submerged vessel and then filled with air to assist in refloating the vessel.

b. A water-tight structure which is sunk by filling with water, and raised by pumping it out, used to close a sluiceway or entrance to a dock. It works in grooves in the dock walls, and acts as a lock-gate. See Plate XIX. page 884.

Pon-ton'-bridge. (*Military Engineering.*) A temporary military bridge supported on flat-bottomed boats or floats, termed *pontons*.

The use of boats or floats for supporting temporary bridges is of great antiquity.

Darius Hytaspes and his army crossed the Bosphorus on a bridge of this kind in order to invade Greece, 493 B. C., and his successor Xerxes constructed one across the Hellespont, 480 B. C., for the same purpose, of which we have a description in Herodotus. Its length was 500 paces. Ships were used as pontons; suspension-cords of flax and *biblos* united them; transverse beams were laid on the ropes, planks on the beams, soil on the planks, and the armies crossed thereon.

Cyrus, according to Xenophon, threw over the Meander a bridge supported on seven boats. Pompey crossed the Euphrates by a boat-bridge during the Mithridatic war.

Portable bridges were designed by the Marquis of Worcester, 1655; Leonardo da Vinci, 1452–1520; Bourne, 1578; and by others a little later. It was so much the fashion of that day to conceal the particular points of invention under the obscurity of general phrases, that the exact devices can hardly be ascertained. The Marquis states that a six-horse wagon will carry a bridge to span a river half a mile broad.

The ponton equipage of the United States army consists of wooden bateaux, 31 feet long, 2 feet 6 inches deep, 5 feet 4 inches wide at top, and 4 feet at bottom, tapering to a width of 4 feet at the bow and 2 at the stern.

To construct the bridge, the bateaux are placed at distances of 13 feet 10 inches apart, and moored by anchors both up and down stream; they are then connected to each other by spring-lines extending from the bow of each to the stern of the next, and so on reciprocally; over the gunwales of the boats are laid the *balks* or beams in such a way that each shall extend quite across each adjacent pair of boats; over the balks are laid the *decking-plank* (*chesses*), which again are kept in place by pieces of scantling termed side-rails, the whole being firmly lashed to each other and to the boats by cords. The width of roadway is eleven feet. A bridge of this construction and dimensions has been found to be amply strong to sustain any weight which will be likely to be brought on it in service.

The pontons with their appurtenances are carried on wagons which follow in the train of the army.

Boats of corrugated iron, being lighter than those of wood, have also been employed.

Colonel Blanchard's pontons, used in the English service, are made of tin-plate, 22 feet long, 2½ feet in diameter, with hemispherical ends, and divided by several longitudinal and transverse partitions to act as braces and prevent their sinking if pierced by a shot or by accident.

Colonel Pasley's copper ponton is also used in the same service. It is in the form of a decked canoe, 22 feet long, 2 feet 8 inches in width and depth. It has a timber frame covered with sheet-copper. The ponton is formed of two equal parts, which are locked together for use and dislocated for transportation. Each half has also divisional diaphragms, which prevent its sinking if one chamber be pierced below the water-line. Small pumps are provided for discharging water to keep a ponton afloat in an emergency.

The system adopted is to make up the bridge in a series of rafts, each of which consists of two pontons united by the balks or joists so as to be about twelve feet apart, the ends of the balks resting on frames lying longitudinally upon and lashed to the pontons. The rafts are then floated into position, moored and united by balks, which form them into a continuous bridge frame, which supports the *chesses*, or planking.

The complement of men is 1 non-commissioned officer and 6 privates to a pair of pontons. The time occupied under favorable circumstances is 15 minutes to unload and form the raft, and another 15 minutes to put all the rafts together ready for the passage of troops.

A *flying-bridge* is merely a boat which, being made fast to a cable attached to an anchor up stream, is propelled across by the action of the current against its side, its head being kept in the proper direction by an oar; for this purpose the cable should be about 1½ times the width of the river to be crossed. See MILITARY BRIDGE.

Po'ny-chaise. A lady's low chaise, to be drawn by a pony or two.

Po'ny-en'gine. A locomotive-engine kept at a railroad station for moving cars and making up trains.

Pool'er. A stick for stirring the vats of a tannery.

Poop. 1. (*Shipbuilding.*) *a*. The aftermost, highest part of the hull.

b. A deck over the after part of a spar-deck, abaft the mizzen.

2. The roof truss.

Poop-cab'in. (*Shipbuilding.*) The apartment in a poop.

Poop-lan'tern. (*Nautical.*) A lantern carried on the taffrail at night to indicate a flag-ship or act as a signal when a ship is moored bow and stern.

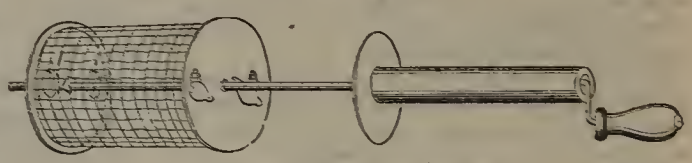
Pop'lin. (*Fabric.*) A stuff having a silken warp and woolen weft, in this respect resembling bombazine. Dublin has attained preëminence in this particular branch of manufacture, the *Irish* poplins being widely and favorably known.

A silk and worsted stuff, watered, figured, brocaded, or tissued. Originally an all-silk French goods. Irish poplins have a silk warp and worsted weft, and in the common grades cotton or flax is mixed with the silk.

Pop'per. A domestic implement for popping corn. It is usually a wire basket, which is held over the fire and shaken or revolved so as to keep the corn moving.

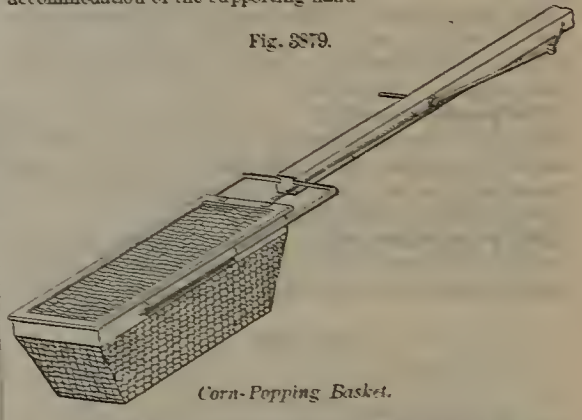
In Fig. 3878, the gauze cylinder has a lengthened crank-shaft by which it is turned, and a sleeve-handle and screen-plate for accommodation of the supporting hand

Fig. 3878



Popper and Roaster

Fig. 3879.



Corn-Popping Basket.

In Fig. 3879, the corn is placed in a gauze case reciprocated in a gauze tray by a crank upon the staff.

Pop'pet. 1. (*Shipbuilding.*) *a*. Poppets are square timbers (*shores*) erected on the *bilgeways* and forming a part of the cradle on which the vessel rests in launching. The heads of the poppets are confined by a plank bolted to the bottom of the ship, and their heels rest on sole-pieces on the upper sides of the bilgeways.

b. Small stakes on the gunwale of a boat to form rowlocks and support the wash-strake.

2. One of the *heads* of a lathe.

3. (*Steam-engine.*) A valve having an axial stem and reciprocating vertically on its seat. See PUPPET-VALVE.

Pop'pet-head. (*Turning.*) The part of a lathe which holds the back-center and can be fixed to any part of the bed.

Por'ce-lain. Pottery — using the word as generic — made of a material which becomes vitrified and translucent by burning. The term *burning* is here used in preference to *baking*, as that term is applicable to the first heating which converts the plastic clay into *biscuit*.

The tests of porcelain, as contradistinguished from pottery in its specific sense, are the glassy fracture, its clear ringing sound when struck, the homogeneity of its outer and inner coat, its resistance to fire, water, and all acids but fluorhydric.

Porcelain is said to have been invented in China the fourth century A. D. The name is derived from *porcellana* (Portuguese), a fine white shell which was held to resemble the ware.

The potter's wheel is shown among the very earliest of the Egyptian mural paintings. In more than one instance the wheel is shown as being used in the molding of man from clay.

Fig. 3880.

Kneph, the Creative Spirit of the Egyptians, making Man on the Potter's Wheel from Clay.

Porcelain, as well as other kinds of earthenware, is found in the Egyptian tombs. One green porcelain jar has hieroglyphics which define it as Egyptian. Other vases from Thebes, Sakkarah, and Ghiseh are evidently Chinese, and indicate the commercial acquaintance of the two peoples.

Two of these bottles were brought to England by Mr. Rawlinson, another was found in a previously unopened tomb, and others are in European museums.

They are of a rather inferior article of porcelain, and probably contained a drug, perfume, or dye when imported.

Many blue porcelain emblems and images are in the Abbott Egyptian Collection, New York.

Many of the cups and vases discovered at Thebes are elegant in form, proportion, and coloring, and are deeply vitrified in burning.

The porcelain of China is believed to have been known to the Romans under the name of *murrhina vasa* or *murrea vasa*, although they had no idea of its mode of formation. It was first introduced by Pompey, who dedicated cups of this kind to Jupiter Capitolinus. They are mentioned by Pliny, Martial, and

Fig. 3881.

Chinese Bottles.

others. Pliny's guess at the way in which they are formed, "a substance formed by a moisture thickened in the earth by heat," shows that they were not glass. The latter was no novelty in the time of Pliny. See GLASS.

Oriental porcelain was imported into Europe by the Portuguese in the beginning of the sixteenth century; but this was not the first of the trade, though perhaps the first important venture in the way of porcelain merchandising. Early in the fifteenth century, the French king, Charles VII., had pieces in his collection; in 1487, Lorenzo de Medici received several valuable porcelain vases from the Sultan of Egypt. The Marchese Campori of Modena cites a letter, written in 1567, referring to Bernardo Carnigiani as the rediscoverer of the art of making porcelain. This was more than a century before Böttcher, who was, however, an original (not first) discoverer.

The incident which directed Böttcher's attention to the subject was observing the contents of some crucibles in which some alchemical preparations had been heated. This was noticed to resemble porcelain, which then was a curiosity and of great value. The material which gave the peculiar character to the compound was ascertained to be a fine white clay, found on the road near Aue, which was excessively tenacious and clammy, but capable when dry of being reduced to a very fine powder, so that it had been used for hair-powder and went by the name of "Schnorr's white earth." It proved to be kaolin.

The French porcelain works were first established at St. Cloud, in 1695, by Louis XIV.; at Vincennes, 1740; removed to Sèvres, 1786.

The Meissen, Saxony, porcelain manufactory was established by Augustus II., Elector of Saxony, in 1710. Böttcher invented the hard paste in 1706; the red ware like jasper, in 1711; white porcelain, in 1709; the perfect, white kind, in 1715. He died in 1719. Höroldt introduced gilding and painting in 1720; modeled groups, in 1731; porcelain made in England, at Bow, in 1698. Wedgwood ware was first patented, 1762.

Porcelain may be distinguished from the coarser earthenware as a pottery which is fine grained, compact, very hard, and somewhat translucid. The latter quality is derived from its partial vitrification. It has various colors.

Porcelain is divided into hard and tender. The former is made in Germany and in Asia, and the latter is held to include the ironstone china and similar ware, so heavily manufactured in England. Kaolin is the principal ingredient, mixed with a peculiar mineral, as related elsewhere in this article in a report of the French emissary who went to China to discover the secret of the manufacture. Its glaze is earthy and non-metallic.

Tender porcelain, on the contrary, consists of a vitreous frit, which is rendered opaque and less fusible by mixture with a calcareous or marshy clay. Its glaze is an artificial glass composed of lead, silica, and an alkali. This porcelain would melt at the heat which the other requires to burn it.

It is held to occupy a place between the hard porcelain and fine stone ware. It differs from the first in the friability of its paste, and its metallic glaze, and from the second in its transparency and stronger glaze.

The information gathered from the French emissary who went to China to spy out the process is published by the Royal Academy of Paris, and is in substance as follows: —

There are three materials employed in forming the body of the ware, but all the three are never used at once.

The first is called *petuntse*. It contains scattered shining particles, is fine grained, and is quarried from certain rocks. It is prepared for use by first breaking it with hammers, then grinding it in mortars with iron pestles, and, lastly, it is washed over, taking only the white creamy matter which floats on the surface, which, after being dried and pressed into small cakes, is fit for use.

The second material is called *kaolin*, and appears to be porcelain clay, namely, that which results from the decomposition of feldspar. It is described as occurring in lumps in the clefts of mountains, covered with a reddish earth. It is prepared for use exactly in the same manner as the *petuntse*.

The third material is called *hoaché*. It is used instead of kaolin. It has a smooth, soapy feel, and no doubt is either steatite or soapstone or agalmatolite. It is prepared in the same manner as the preceding. Porcelain made with this latter is much dearer than that made with kaolin. It has an exceedingly fine grain, and is very light, but at the same time more fragile, and it is not easy to hit on the precise degree of heat that suits it. For the finest porcelain, four parts of hoaché are added to one of petuntse. Sometimes the body of the ware is made with kaolin; and then the article, when dry, is dipped in the hoaché, brought to the consistency of cream; what adheres forms a thin layer, on which, when dry, are laid the colors and the glaze; and thus a porcelain finer than the common is obtained. Hoaché is also laid with a pencil, before glazing, on those parts of the common porcelain that are intended to have an ivory-white color.

For the fine kaolin porcelains, equal parts of that substance and of petuntse are employed; for the less fine, two parts of the former and three of the latter. The ingredients being put together in due proportions, the mass is carefully tempered and kneaded by hand, and then the ware is wrought on the wheel, or for articles of irregular figure, which cannot be thus formed, is made by pressing the composition into molds and then uniting the several pieces by moist clay. The piece, being formed, is very carefully dried, and is then covered with the glaze. The white semi-transparent glaze is thus prepared: The whitest petuntse with green spots is pulverized and washed over, as already described; and to one hundred parts of the cream thus obtained is added one part of *che-kao* (burnt alum or perhaps gypsum) previously pulverized. A caustic potash lye is also

prepared, into which *che-kao* is stirred, and the cream thus produced is collected. The two creams are then mixed together in the proportion of ten measures of the former to one of the latter. This composition it is which gives to porcelain glaze its whiteness and luster.

A brown glaze is made of common yellow clay washed over and brought to the consistence of cream and then mixed with the former glaze. If the brown glaze is not to cover the whole of the surface, wet paper is laid on the reserved parts, which, after the glaze has been put on and has ceased to be fluid, is removed, and such blank parts are then painted in colors and covered with the common white glaze.

When the glaze is thoroughly dry, the ware is put into the furnace for the first time, whence it appears that the ware is never in the state of biscuit, — a circumstance in which the process materially differs from that adopted by the European manufacturers, who put on the glaze after the first firing of the ware.

The flux used with those colors that are laid on over the glaze is made of quartz, calcined and pulverized, and then mixed with ceruse in the proportion of one of quartz to two of ceruse.

Red is given by peroxide of iron, produced by calcining green vitriol; and a finer red is made of copper, but the particular process is kept secret.

The enamel colors are tempered to the proper consistence by a solution of glue, except those into the composition of which the ceruse enters; these latter are tempered only with water.

Petuntse and *kaolin* (Chinese names) are both derived from feldspar, which consists of silica, alumina, and potash. Kaolin consists of decomposed feldspar, and petuntse is the powder of *undecomposed* feldspar. The radical difference seems to be that by decomposition and exposure to the air the kaolin has acquired plasticity, has become a *clay*. This being the case, it is easy to conceive the propriety of keeping the prepared clay in a condition to improve by exposure and age, before working it. Marco Polo, who was from 1274 to 1291 in the service of Kublai Khan, the Conqueror of China, states that the heaps of porcelain clay were exposed in China for thirty to forty years before using; so that men gathered the materials for their children and grandchildren.

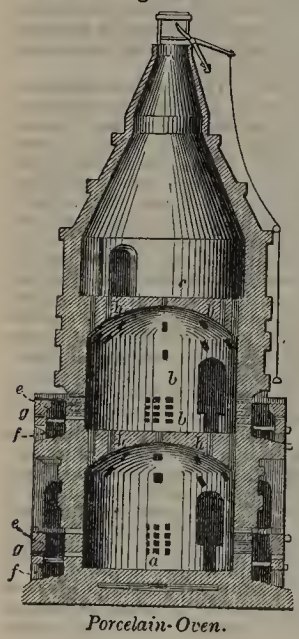
The other material mentioned is hoaché, and probably, as the Père d'Entrecolles remarks, is steatite; which is a compound of silica and magnesia

We cannot go into all the particulars of the history of the art, nor describe the ingredients and compositions of the porcelains of China, Dresden, Sèvres, Berlin, Vienna, Bohemia, but must refer our readers to Birch's "History of Ancient Pottery" (1858); Marryat's "History of Pottery and Porcelain, Medieval and Modern" (1857); and Brogniart's "Arts Céramiques."

Por'ce-lain-cem'ent. Stir plaster of Paris into a thick solution of gum-arabic; apply with a brush.

Por'ce-lain-gild'ing. Porcelain is gilded with a magma of gold, quicksilver, and flux, thinned with turpentine and oil, like paint, and laid on with a brush. A stencil-plate and powdered charcoal may be used to delineate the design upon an adhesive surface spread upon the ware. The black magma turns to a dead gold color by firing as the volatile ingredients are sublimed, and the brightness of gold is obtained by burnishing.

Fig. 3882.



Porcelain-Oven.

Por'ce-lain-mill. An arrangement of vats for the mixing and decantation of slip, straining and feeding it to the grinder, which consists of a runner and bed-stone of chert (hornstone), by which the feldspar and flint are reduced to an impalpable and creamy consistence.

Por'ce-lain-ov'en. The porcelain-oven (Fig. 3882) is built in three stages, *a b c*; the conical top has an opening which serves as the chimney. The lower stages *a b* are used for "strong firing" the porcelain, while the upper stage *c*, called the *howell*, *crown*, or *cowl*, serves for "raw burning." Each of the lower stages is provided with fireplaces *e e* and ash-pits *f f*, the openings of which are closed while burning. The fuel (wood) is introduced through the openings *g g*, and openings *h h* permit the circulation of the hot gases through the oven; *i* is the entrance-door.

Por'ce-lain-pa'per. A kind of French glazed, fancy paper. Figured, painted, or gilt.

Por'ce-lain-pic'ture. A kind of photographic picture in which a positive is produced upon a milky or semi-translucent glass. The *collodio-chloride* process is frequently adopted, which see.

Por'ce-lain-print'ing. The transferring of an impression of an engraving to porcelain in the *biscuit* or the glazed condition. The former is called *press-printing;* the latter, *bat-printing.*

In *press-printing*, the engraving is very heavy, is taken on *pottery-tissue* paper, transferred to the biscuit by rubbing with soaped flannel and then a roll of flannel; the paper is then damped off, and the oil of the ink driven off by heating the biscuit in a hardening-kiln, previous to glazing.

In *bat-printing*, the lines of the engraving are more delicate. The impression is taken in linseed-oil on a slab of damp glue, and transferred from thence to the glazed ware. Color is then dusted on to the oil, and the ware is fired in an enamel kiln.

Printing on porcelain, or the transferring of printed impressions to *biscuit*, was introduced by Dr. Wale of Worcester about 1751. The Prussians refer the discovery of the process to the year 1757.

Porch. (*Architecture.*) A covered entrance to a building. With a row of columns it is a portico.

Porch-post Sup-port'. A casting placed between the foot of a post and the floor of a porch to prevent decay of the two at that point.

Por'cu-pine. (*Fiber.*) A heckling apparatus for flax; or a cylindrical heckle for worsted yarn.

Por'phy-ri-za'tion. A mode of grinding substances by a muller upon a slab. Porphyry, from its extreme hardness, is eminently suitable, and has given its name to the process.

Triturating mortars of porphyry, 29 inches in diameter, have been made in France, but are very expensive, owing to the difficulty of working the material. See ARRASTRA; MORTAR; ORE-MILL.

Por'phy-ry. 1. A rock having a hard base, usually feldspathic, through which crystals of feldspar are disseminated.

2. Also, among stone-cutters, a hard and valuable description of marble. There are varieties of red, green, and gray colors.

Port. 1. (*Shipbuilding.*) *a.* A framed opening in a ship's side through which a gun is fired, a hawser passed out, or cargo passed in or out. They are known as *gun*-ports, *ballast*-ports, *cargo*-ports, etc., and are closed by *shutters* or *lids.*

Row-ports are for sweeps.

The aft and forward ports are known as *stern*, *quarter*, or *bridle* ports; also as *chase*-ports, *stern-chase* ports, etc.

A *half*-port is one hinged to the sill of the port and closing the latter up to the line of metal of the gun.

A *light*-port is an opening provided with a glazed lid or *side-light.* A water-tight shutter over the *side-light* is called a *dead-light*, and is used in stormy weather.

An *air*-port is an opening through the side below decks for ventilation.

2. (*Nautical.*) The left side of a vessel to a person standing on deck and facing toward the bows. It was formerly called *larboard.*

3. (*Steam-engine and Hydraulics.*) A steam opening. An aperture for the passage of a fluid; as, a *steam*-port, *water*-port, *gas*-port.

The entering port for live steam is the *inlet* or *induction* port; the port of departure is the *outlet*, *eduction*, or *exhaust* port.

4. (*Harness.*) The curve in the mouth-piece of some bridle-bits.

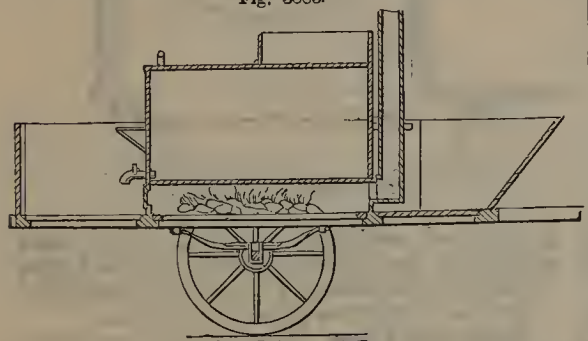
Port-bit. (*Harness.*) A general name for all bits having a *port* mouth-piece.

Port'a-ble Boat. One adapted for being reduced to a small compass for land transportation. Various devices of this kind have become the subject of patents. See FOLDING-BOAT.

One form has diagonal thwarts and ribs pivoted at their centers by upright standards and having hinge-joints at their ends; it is longitudinal, strengthened by two pieces one above and one, corresponding to a keelson, below; the frame is covered with water-proof material, and may be folded up so as to occupy a space not exceeding the length of the ribs. In another, the longitudinal pieces are hinged, admitting of being folded; the transverse pieces are scarfed together and secured by bands and quoins so as to be readily disunited. The floor and sides may be of plank, or the frame may be covered with canvas so laced as to be quickly applied and removed.

The frame of a third form has an inner and outer keel, to the former of which a folding wing on each side is hinged; two iron rods running from end to

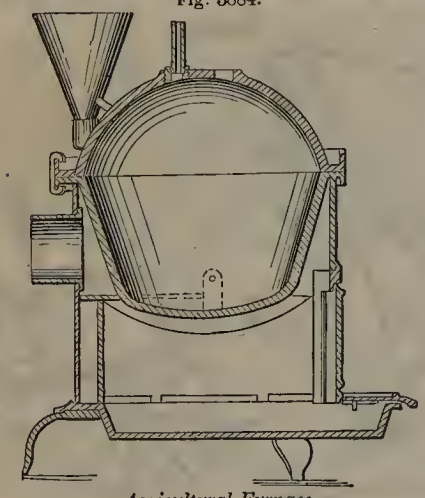
Fig. 3883.



Roofing Boiler and Furnace.

end are pivoted so that they can be brought near together. The middle rib, seat, and cross-bar are turned upon a pivoted standard until parallel with the keel, and the wings folded in upon them. The

Fig. 3884.



Agricultural Furnace.

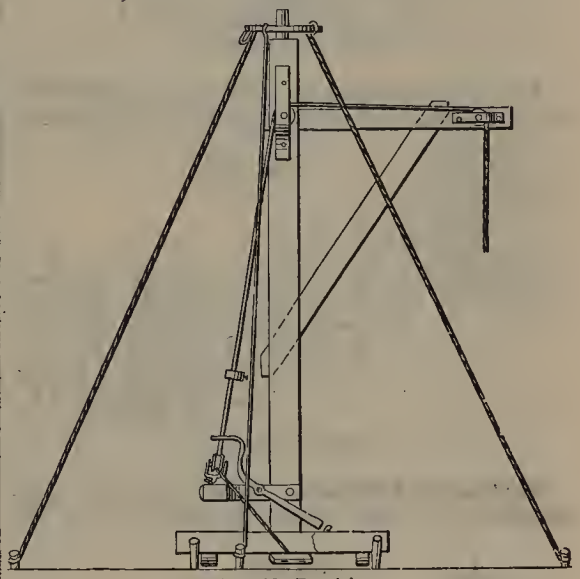
frame has a flexible covering. See also FOLDING-BOAT; BUGGY-BOAT; PONTON; CANOE.

Port'a-ble Boil'er and Fur'nace. A furnace on wheels for paving or roofing purposes, to heat the tar or other material. In the example, the furnace, boiler, and other incidentals are mounted on a spring dray for convenient transportation.

Fig. 3884 is an agricultural furnace for cooking feed for stock.

Port'a-ble Der'rick. One for stacking hay in

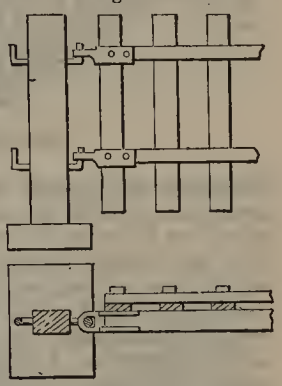
Fig. 3885.



Portable Derrick.

the field, loading stone in a quarry, or in other situations where it may require to be occasionally moved. In the example, the hoisting-rope has an adjustable block which comes in contact with the trip-lever when the load is at the proper elevation. The tripping of the lever allows the swinging around of the derrick.

Fig. 3886.



Shifting-Panel Fence.

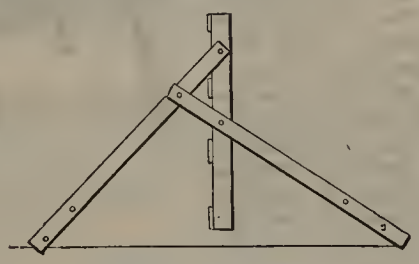
Port'a-ble Fence. (*Husbandry.*) One which may be shifted as convenience may require.

In Fig. 3886, the string-pieces have eyes which engage hooks on the posts.

In Fig. 3887, one brace is pivoted to the other, and the latter to the post.

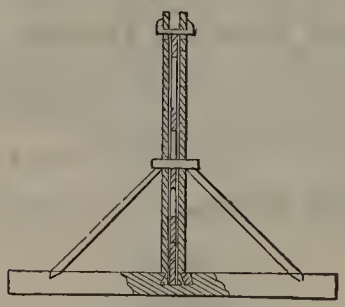
In Fig. 3888, the posts and braces are framed into the sills, and the parts secured by keys and wedges, without nails.

Fig. 3887.



Diagonal-Brace Fence.

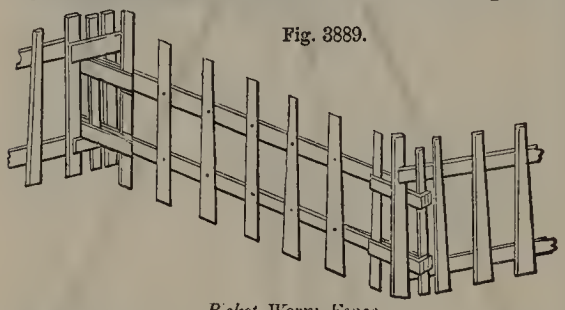
Fig. 3888.



Fence with Sill-Piece.

Figs. 3889 and 3890 are picket-panels, interlocking at the ends. The latter has also a brace-piece.

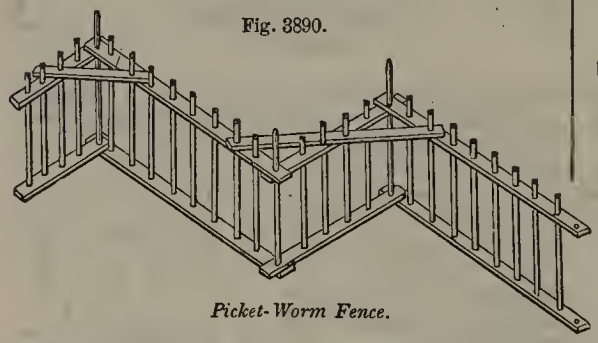
Fig. 3889.



Picket-Worm Fence.

Port'a-ble Fur'nace. Aiken's portable blast-furnace is in three parts, all made out of the

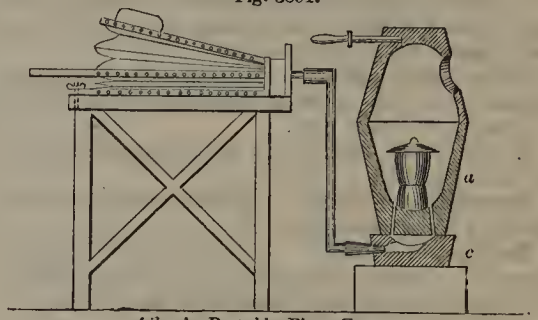
Fig. 3890.



Picket-Worm Fence.

black-lead melting-pots used by goldsmiths. The lower piece *c* is the bottom of one of these pots, cut off so low as only to have a cavity about an inch deep, and ground smooth above and below. The middle piece or fireplace *a* is a larger portion of a similar pot, with a cavity about 6 inches deep, measuring 7½ inches over the top, and being perforated with 6 blast-holes. An upper pot of the same dimensions as the lower one is added to confine the heat and protect the eyes from the glare. A hole allows the exit of the flame and smoke. An iron handle is provided for unshipping the top section when the crucible is to be removed. The bellows are fixed to a heavy stool, the nozzle is received into a hole in the pot *c*, which conducts the blast into the cavity. The furnace is suitable for a laboratory and for metallurgic operations on a small scale.

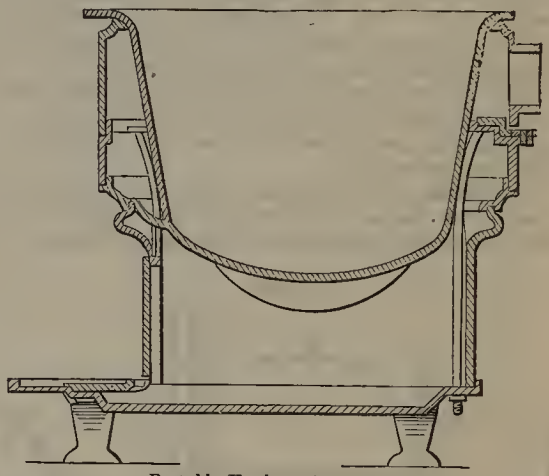
Fig. 3891.



Aiken's Portable Blast-Furnace.

Fig. 3892 is an apparatus for boiling stock feed, tar, or what not. It is made wholly of cast-iron, and the kettle is made to fit into a recess directly over the fire, the whole being so constructed that the

Fig. 3892.



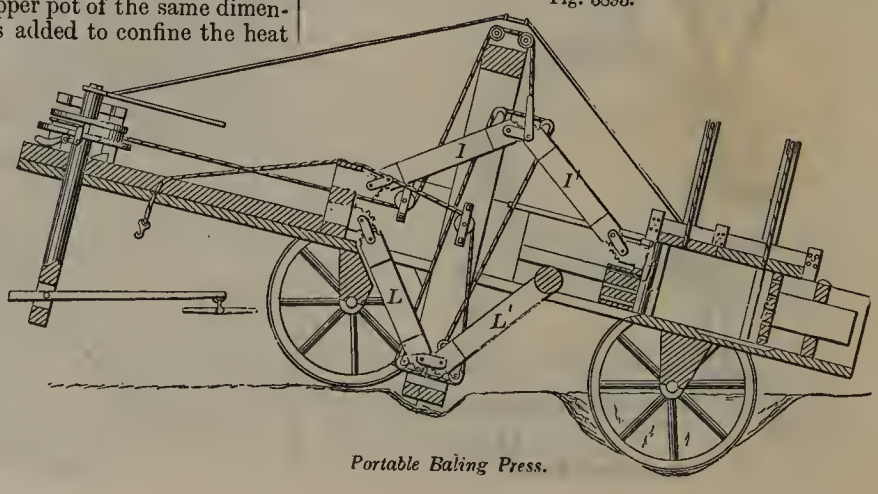
Portable Kettle and Furnace.

products of combustion are made to act more equally on the bottom and sides of the kettle, which is accomplished by a peculiar arrangement of horizontal partition-plates forming flues.

Port'a-ble Press. This may be any one among many of the different mechanical constructions. Placing a press on wheels may be said to constitute it a *portable* press, but the necessities of the case sometimes require peculiarities of construction.

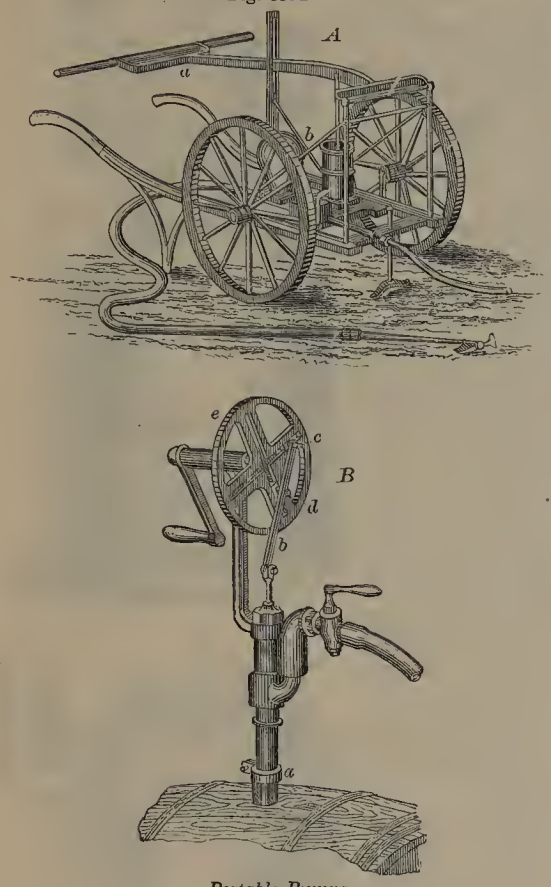
In the example shown, the press is on wheels. The hind wheels are sunk into pits, throwing up the forward end so that draft animals may work the sweep below the fore end, upon

Fig. 3893.



Portable Baling Press.

Fig. 3894.



Portable Pumps.

which is placed the capstan on which winds the rope by which the toggles are worked.

The abutment head of the press-box is adjustable. When operating as a beater, the follower is operated by toggle-arms *l l'*. The arms are drawn up by a cord, which is tripped from its pulley to allow the said arms to descend. For completing the pressure, additional toggle-arms *L L'* are brought in operation. Both pairs of toggle-arms are operated by a single rope in this latter operation. The lids of the box are balanced by weights to assist in their opening. The passages in the heads for introduction of the hoops are recessed beneath to permit the passage of the arm of the operator, and the box bottom is grooved to guide the hoops from side to side beneath the bale.

Port'a-ble Pump. One for use in an emergency, or for watering gardens, or emptying cisterns or casks.

Baddeley's (*A*, Fig. 3894) is a combined suction and force pump, designed for irrigating and manuring purposes. It may also be used as a fire-engine. It is mounted on a carriage, and is operated by means of a brake *a*. An air-chamber *b* enables a continuous stream to be thrown.

Fully and Reece's pump (*B*) is designed for transferring liquids from casks, etc. For this purpose, it is provided with a conical sleeve *a* entering the bung-hole and secured by a clamp-screw. It is operated by a crank which causes two reciprocations of the piston at each revolution by means of the pitman *b*, which has sliding-boxes *c d* working in slots of the arms of the *sloshwheel e*.

Port'a-ble Rail'way. (*Civil Engineering.*) One so constructed as to be taken apart for transportation and relaid at the different points where a temporary track may be required for bringing or removing earth or other materials during the progress of a work.

Peteler's is composed of sections, each 20 feet long, the rails being of wood, faced on top with iron and united by ties mortised therein. The ends of the sections may be united by bolt, mortise, and tenon attachment, or by hooks and eyes.

Light cars capable of holding from one half to one cubic yard of earth, and of form adapted to the requirements of the ground or material to be moved, are used in connection with the road.

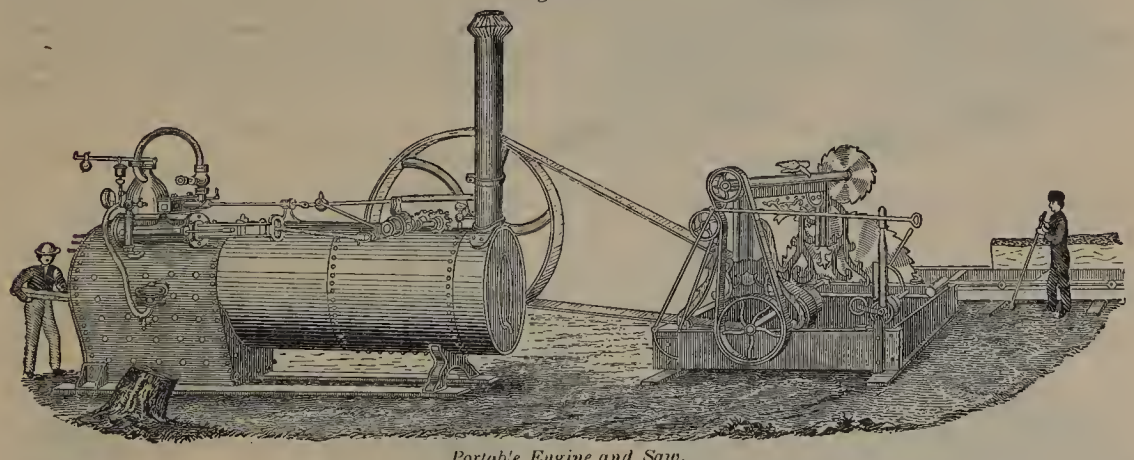
Portable railroads have frequently been made for temporary purposes, such as the conveyance of locomotives, cars, etc., from shops to the permanent way of a railway; also for carrying and dumping earth, gravel, or stone for fillings, embankments, backing of wharf, for ballast and for freight.

Peteler's organized arrangement of detached sections, turnout, frogs, supporting trestles, bridges, crossings, and turn-tables, patented September 4, 1866, has been utilized in some cases where the distance is not great, and found more economical than carts.

Port'a-ble Steam-en'gine. A steam-engine attached to a boiler and capable of easy transportation. It is generally adapted for out-door work. Locomotives and traction-engines are, strictly speaking, portable engines, but are not generally referred to by that name. See LOCOMOTIVE; TRACTION-ENGINE.

Fig. 3895 shows a form of portable engine much used in the West. The engine is secured to a hollow cylindrical bed-plate, which in turn rests in saddles on the boiler. The object of this

Fig. 3895.



Portable Engine and Saw.

bed-plate is to prevent damage to the engine or boiler due to unequal expansion and contraction from the effect of heat. The bed-plate is also made to serve as a feed-water heater by the passage of exhaust steam through it on the way to the smoke-stack. The boiler is of the locomotive pattern.

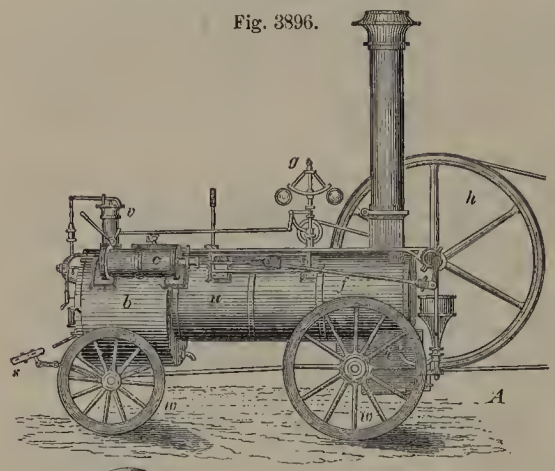
The cut shows the engine at work in the field driving a portable saw-mill.

In Fig. 3896, *A* shows the English form of portable steam-engine for thrashing and grinding grain, grinding bark, pumping, sawing wood, cutting feed, etc. In this, *a* is the tubular boiler with oval fire-grate; *b*, fire-box; *c*, cylinder of engine; *f*, connecting-rod; *g*, governor; *h*, fly-wheel; *i*, cold-water tank, to which is attached the pump for supplying the boiler; *w*, traveling-wheels; *s*, shafts for two horses abreast; *v*, safety-valve.

B, in this figure, is a self-moving engine intended for use with a thrashing-machine, but capable of making short journeys over country roads by its own power and of being used as a traction-engine.

Fig 3897 shows two views of a portable engine adapted for out-door work, and provided with draft attachments for horses.

Fig. 3896.



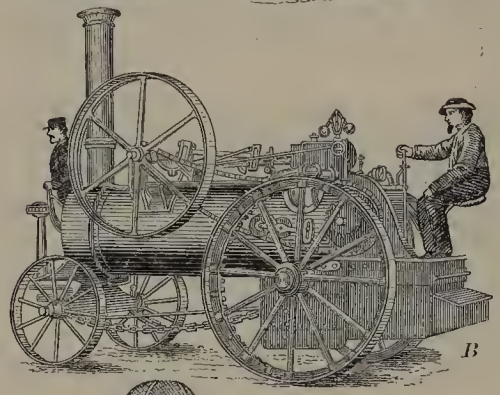
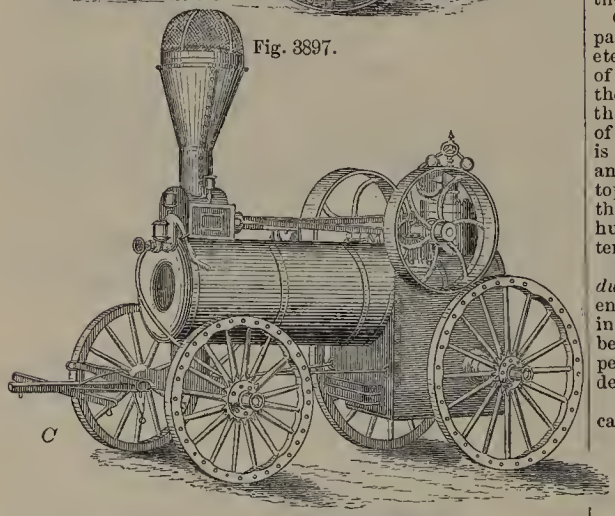
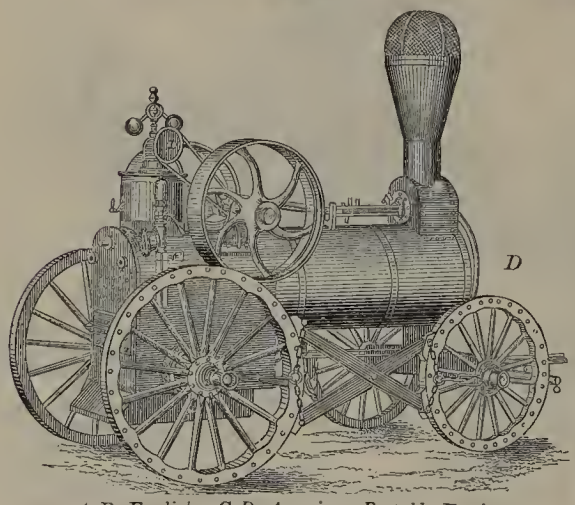


Fig. 3897.





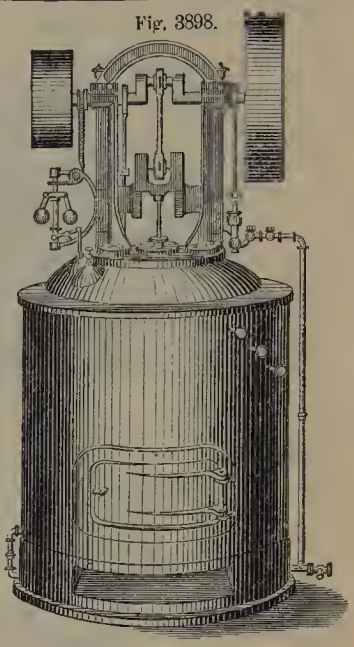
A B, English; C D, American Portable Engines.

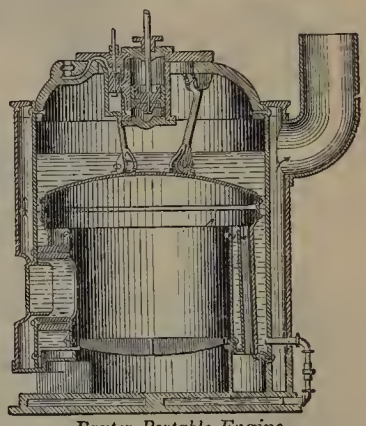
The boilers are of the locomotive pattern, with steam-dome over the fire-box. The steam-cylinder in these engines is in the base of the smoke-stack.

D, Fig. 3897, is provided with a locking brake attachment for the wheels, to prevent vibration while the machine is running.

The Baxter portable engine is mounted on top of an upright boiler, and the cylinder, which is also vertical, is within the steam-dome, whereby it is kept hot, preventing condensation of steam in the cylinder. In Fig. 3898, the upper view shows the arrangement of parts of the engine, while the lower cut is a sectional view, showing the position of the cylinder, piston, steam-chest, valves, and valve-rod. It shows also how the interior of the boiler is braced, so as to give it the requisite strength; the position of the grate and combustion-chamber, and the pipe by which the heated water from the water-bottom is forced into the boiler.

Fig. 3898.





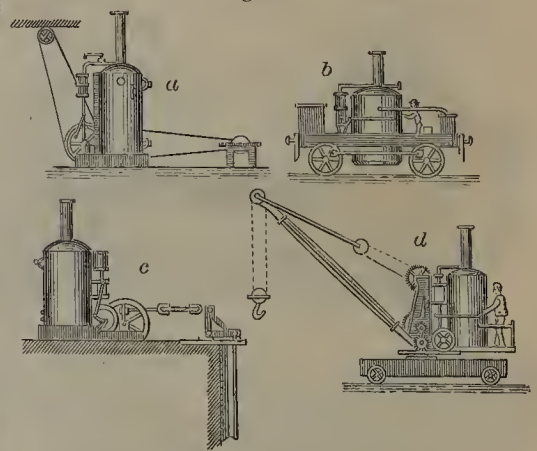
Baxter Portable Engine.

Owing to the comparatively large diameter and the placing of the cylinder below the top of the boiler, the center of gravity of the whole machine is brought down low, and shaking of the top frame, on which the driving-wheel is hung, is to a great extent prevented.

The best reported *duty* of the English portable steam-engine was a 7 horse-power engine built by Hornsby, in which 36 pounds of coal were used in getting up steam; the consumption was 37 pounds per hour, being 5.28 pounds per horse-power per hour, and 370 pounds per day of 10 hours. The Baxter engine has been known to develop 1 horse-power for each 3¼ pounds of coal per hour.

In Fig. 3899, *b d* are forms of portable engines mounted on carriages which can be moved from place to place. The engine

Fig. 3899.



Portable Engines for various Purposes.

and boiler *d* swiveled on the carriage form a counterpoise for the weight on the crane. *b* is a contractor's locomotive. *a* is adapted to hoisting, and *c* to driving a pump.

Port'a-ble Stove. A stove for army, emigrant, or mechanical uses, which require its removal and transportation. Such are used by plumbers, and by those who follow the business of roofing with paper and bituminous compounds, tar, etc. See page 1767.

The stoves are of sheet-iron, and adapted to heat kettles, caldrons, or ovens, as the case may be.

Por'tal. (*Architecture.*) The arch over a door or gateway; an entrance under cover.

Port-cul'lis. (*Fortification.*) A frame of iron or wooden bars sliding in grooves, and capable of being lowered to close a gateway.

Porte-ai-guille'. (*Surgical.*) A fine forceps forming a handle or holder for a needle, having jaws closed by a sliding ring. It is also used for passing a ligature needle around an artery in deep-seated places, out of the reach of an ordinary tenaculum.

Porte-bou-gie'. (*Surgical.*) A silver canula for conducting a bougie into the urethra.

Porte-caus-tique'. (*Surgical.*) An instrument like a porte-crayon for applying a stick of luna-caustic to a deep-seated part.

Porte-cor'don. An instrument made in halves, of whalebone or hard rubber, with an open loop in front, which may be closed by one sliding on the other; it is used for holding or changing the position of the umbilical cord, in obstetrics.

Porte-cray'on. A pencil-case. A handle with sliding jaws to grasp a crayon.

Porte-mèche. (*Surgical.*) A wire instrument having a notch at one end and a button at the other; used to carry a tent or *mèche* into deep ulcers or fistulous openings. See PROBE.

Porte-mon-naie'. A leathern pocket-book for holding money, etc.

Porte-mox'a. (*Surgical.*) An instrument with a ring and handle, and used for applying a moxa to the skin.

Porte-nœud. (*Surgical.*) An instrument for carrying a ligature around the base or pedicle of a tumor.

Porte-pi-erre'. (*Surgical.*) A handle with sliding-jaws to hold a stick of luna-caustic.

Porte-pol'ish-er. A dentist's instrument by which a polishing stick or slip is held and applied. It is like a forceps, and forms a handle for the corundum-points or other abradant.

Por'ter. 1. (*Forging.*) *a.* A long bar of iron attached in continuation of the axis of a heavy forging, whereby it is guided beneath the hammer or into the furnace, being suspended by chains from a crane above. A cross lever fixed to the porter is the means of rotating the forging beneath the hammer.

b. A smaller bar from whose end an article is forged, as a knife-blade, for instance.

2. (*Weaving.*) A weaver's term in Scotland for twenty splits in plain work. In England it is called a *beer*. A *split* is a *dent* of the reed, and when two threads go to a split forty threads go to a *porter*. In England *reeds* are rated by the number of splits to an inch.

Porte-sonde. (*Surgical.*) An instrument resembling a *porte-crayon* or *porte-caustique*, to introduce a *style* or *sonde* into the nasal duct in *fistula lachrymalis*.

Port-fire. A paper tube filled with a composition of niter, sulphur, and mealed gunpowder; formerly used to fire guns. Now superseded by the friction-primer and gun-lock.

The *common port-fire* is sixteen inches long, and is packed with a composition which burns at the rate of about one inch per minute.

The *slow port-fire* consists of paper impregnated with saltpeter and rolled into a solid cylinder about sixteen inches long. It will burn three or four hours.

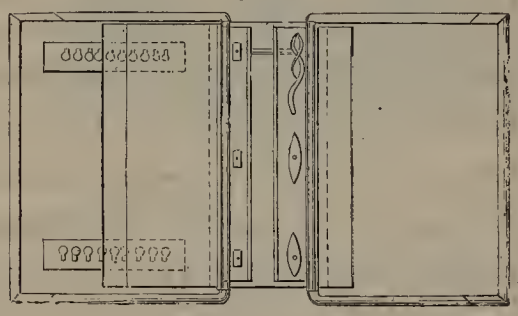
Port-fires may be made by boiling square rods of poplar or other light porous wood in a solution composed of one quart of water to one pound of nitrate of lead for six hours. These are then dried and afterward boiled in spirits of turpentine. One yard will burn three hours

Port-fire Clip'per. A nippers for cutting off the ends of port-fires.

Port-flange. (*Shipbuilding.*) A batten above the port to keep drip from entering.

Port-fol'io. A case for holding loose drawings or papers. That shown has an adjustable back-

Fig. 3900.

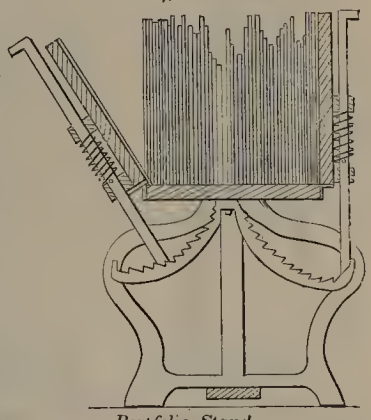


Expansible Portfolio.

piece, which may be extended or contracted in such a way as to increase or diminish the distance between the side covers, and adjust them in any desired position, for the purpose of accommodating any number of sheets of paper. See also PAPER-FILE.

Port-fol'io-stand. A piece of furniture for holding folios, music-books, or engravings. In that shown, the side wings can be turned down and adjusted at any desired inclination, and the portfolio opened without removing it from the stand.

Fig. 3901.



Portfolio-Stand.

Port-hole. 1. (*Shipbuilding.*) An embrasure in a ship's side.

2. (*Steam.*) The steam-passage into or from the cylinder; an *induction* or *eduction* port.

Port-hole Clos'er. (*Nautical.*) A shutter to close a submarine port; opened for the projection of a torpedo spar or the firing of submarine ordnance.

Por'ti-co. (*Architecture.*) *a.* A sheltered walk with columns.

b. A covered colonnade at the entrance of a building.

c. A porch or gateway.

Port'land Cem'ent. A silicate of lime and alumina obtained by calcination of the stone quarried at Portland on the south coast of England.

A hydraulic lime obtained by the calcination of argillaceous limestone, such as the septaria and lias rocks. Also obtained by the calcination of chalk and clay together. See HYDRAULIC CEMENT.

Port-lan'yard. (*Nautical.*) The rope to draw up a port-lid.

Port-lid. (*Shipbuilding.*) A shutter for closing a *port-hole* in stormy weather. It is hung by hinges above; is held up by ring-bolts and a chain or rope called a *port-pendant;* is secured by bolts, and has *bull's-eyes* for lighting 'tween-decks.

The port-lids of the upper decks are sometimes in two parts. The lower is hung with hinges below, and falls. It is called the *bucklar.* The upper is a half-port to put in by hand, or is hinged above.

Port-man'teau. A hand-trunk. Literally, a *cloak-bag.*

Port Mouth-bit. (*Menage.*) A bridle-bit with a fixed mouth-piece having a light arch.

Port-pen'dant. (*Nautical.*) A tackle to trice the lid of a lower-deck port. It is connected to a ring-bolt on the lid.

Port-rig'gle. (*Nautical.*) A piece of wood nailed over a port to carry off the water.

Port-rope. (*Nautical.*) The lanyard of a port-lid.

Port-sail. (*Nautical.*) A waste sail extended between the ballast-port and ballast-lighter.

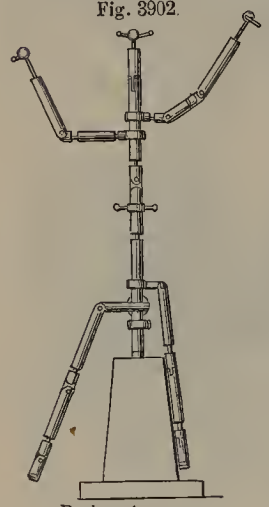
Port-sash. (*Shipbuilding.*) A half-port fitted with sash, to light a cabin.

Port-sill. (*Shipbuilding.*) A short timber lining the port in a ship. Known as *upper, side,* and *lower* port-sills.

Port-tack'le. (*Nautical.*) The purchase for hauling up the lower-deck ports.

Pos'ing-ap'pa-ra'tus. A contrivance for steadying a person in a *pose* or position for a portrait, especially before the camera. The example has a body-rest provided with flexor joints and extension torsion joints, leg-rests, and arm-rest.

Fig. 3902.



Posing-Apparatus.

Po-si'tion-mi-crom'e-ter. (*Optics.*) A micrometer for measuring angles of position, having a single thread or wire which is carried around the common focus of the object-glass and eye-glass, and in a plane perpendicular to the axis of the telescope, the angle being indicated on the graduated circle of the instrument.

Pos'i-tive. 1. *a.* (*Voltaic Electricity.*) The metal, zinc (usually) in the voltaic battery, the pole being called the *anode.*

The negative may be coke, carbon, silver, platinum, or copper, and this pole is called the *cathode.*

The following is the order of the metals, the upper being the most positive: —

Zinc.	Bismuth.
Cadmium.	Nickel.
Tin.	Silver.
Iron.	Antimony.
Lead.	Gold.
Copper.	Platinum.

b. (*Vitreous Electricity.*) According to Dr. Franklin's theory and nomenclature, that which a body contains above its natural quantity.

The terms *positive* and *negative,* as applied in electric science, were used by Franklin in 1747; the terms *vitreous* and *resinous* electricity, by Dufay, in 1734–37.

2. (*Photography.*) A photographic print in which the lights and shades have their natural relation, as distinguished from a negative, in which they are reversed.

Pos'i-tive Eye-piece. A combination of lenses at the eye end of a telescope or microscope, consisting of two plano-convex lenses in which the convex sides of the glasses are turned toward each other. See NEGATIVE EYE-PIECE.

Its principal use is in the *micrometer,* and it is often called the micrometer eye-piece, being used to measure a magnified image.

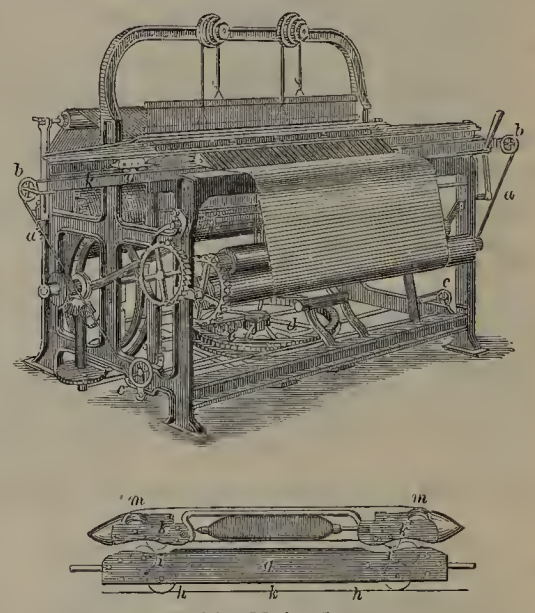
The lenses are separated by a distance a little less than the focal distance of the one nearest to the eye, the image of the object being viewed beyond both lenses.

Pos'i-tive Mo'tion. One derived from the prime mover by complete connection of the intermediate mechanism, in contradistinction to that which acts by the gravitation, friction, elasticity, or other agency residing in the limb or part to be moved.

Pos'i-tive-mo'tion Loom. A loom in which a definite motion both in velocity and amount is imparted to the shuttle.

In Lyall's, this is effected by means of a cylindrical band *a* (Fig. 3903), which passes over and under the pulleys *b b c c,* motion being imparted by the band-wheel *d* actuated by the reciprocating rack *e* and pinion *f,* and is attached to each end of the carriage *g.* The carriage has two sets of wheels *h h i i,* the lower of which roll upon the upper surface of the raceway *k;* the pivots of these wheels turn in slotted bearings, allowing a limited amount of play, and their upper surfaces turn against the lower surfaces of the wheels *i i,* the upper portion of whose peripheries run in contact with the warp-threads. These cause the wheels *k' k'* in the shuttle to turn at precisely the same speed in an opposite direction, so that no lateral motion is imparted to the warp-threads over which they pass. The wheels *m m* roll on the under surface of a beveled rail, which keeps the shuttle down to its work.

Fig 3903.



Positive-Motion Loom.

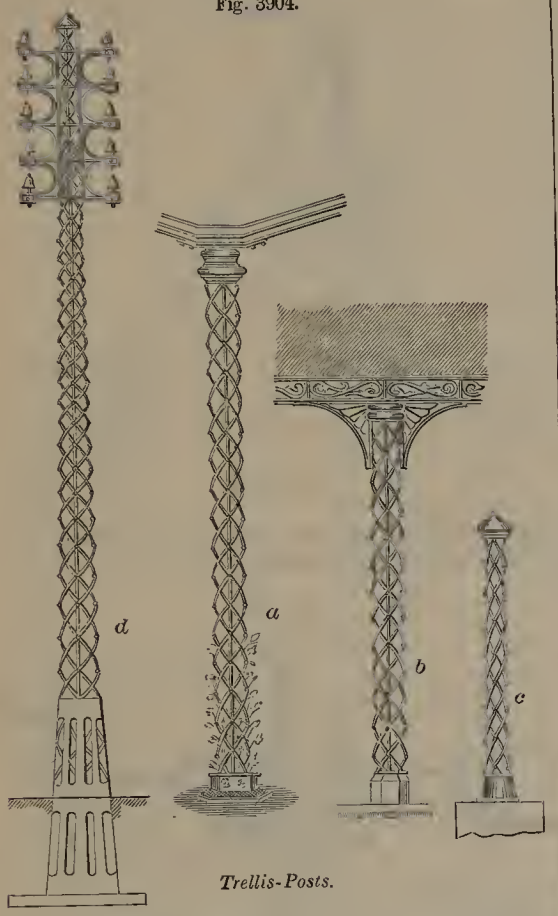
Post. 1. (*Carpentry.*) An upright timber in a frame; as, *king*-post, *queen*-post, *corner*-post, *door*-post, *crown*-post, etc.

2. A pillar or column in a structure.

The celebrated Phœnix post, used extensively for posts and girders for iron structures, is made of four flanged pieces riveted together.

a b are trellis-posts for light superstructures.

Fig. 3904.

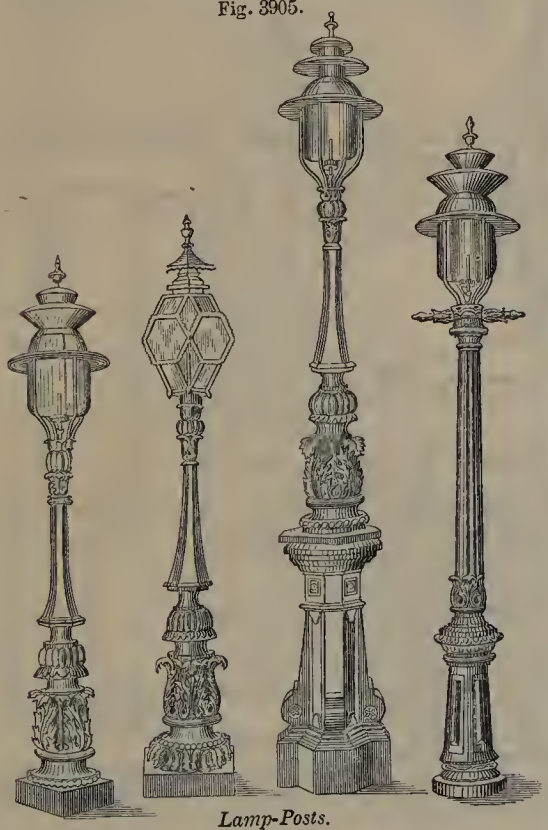


Trellis-Posts.

3. A vertical pillar forming a part of a fence (*c*), or for holding aloft telegraph-wires (*d*).

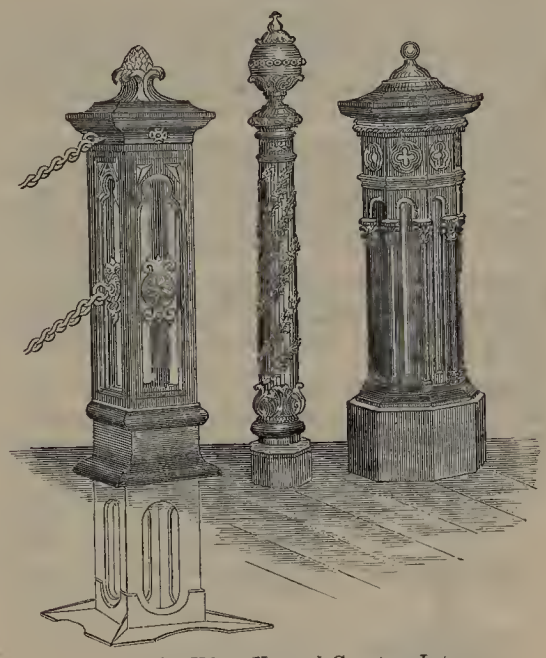
4. (*Furniture.*) *a.* One of the uprights of a bedstead.

Fig. 3905.



Lamp-Posts.

Fig. 3906.



Posts for Urban Use and Cemetery Lots.

b. One of the standards of a chair-back.

5. (*Mining.*) One of the pillars of coal or ore which support the ceiling of a mine.

6. (*Paper-making.*) *a.* A pile of one hundred and forty-four sheets of hand-made paper, fresh from the mold, and made up with a web of felt between each sheet, ready for the first pressure in a screw-press. This is a *felt*-post.

b. A *white* post is the pile of paper sheets when the felts are removed.

c. A size of writing-paper, so called because its original water-mark was a postman's horn.

Twelve varieties of post paper are made in England, of three sizes and various grades of thickness. They are as follows: —

	Size.	Weight per Ream.
Extra large thick post	22¼×17¼ inches.	25 pounds.
Extra large thin post	22¼×17¼ "	18 "
Extra large bank post	22¼×17¼ "	13 "
Large thick post	21 ×16½ "	22 "
Large middle post	21 ×16½ "	19 "
Large thin post	21 ×16½ "	16 "
Large bank post	21 ×16½ "	11 "
Extra thick post	19 ×15¼ "	25 "
Thick post	19 ×15¼ "	20 "
Middle post	19 ×15¼ "	17 "
Thin post	19 ×15¼ "	14 "
Bank post	19 ×15¼ "	7 "

Post paper is seldom sold in the *folio*, that is, *flat*, but is cut in halves, folded, and forms quarto post, or common letter-paper.

Cut again and folded, it becomes octavo post, or note-paper. Again cut and refolded, it becomes 16mo, or small note.

Post'al-car. A railway-car specially arranged for the reception, distribution, and delivery of mail matter. Some recently introduced on the Michigan Central Railroad are 48 feet in length, two thirds of the interior being occupied by cases for letters and papers, arranged in semicircular form, and by distributing-tables; the remainder is used as a "through-mail room," where the bags are placed after distribution. A patent bag-catcher, which snatches the mail-bags from cranes at the different stations as the train passes, is fixed to each door of the car.

Post'age-stamp. A stamp attached to a letter or package, to pay for its carriage by mail.

Postage-stamps were in use in Paris in the reign of Louis XIV., 1653. A private post, under royal authority, was established by M. Velayer, August 16, 1653, a stamp being attached to pay for the transportation of the answer. The stamps were on sale at different public places, and had a portrait of the king. They were sold at one sous each. Boxes were placed at street-corners for the reception of the letters, which were collected three times a day.

Postage-stamps for prepayment of letters were adopted in England about 1840, and about eight years afterward in France. Subsequently the idea spread to almost all civilized nations.

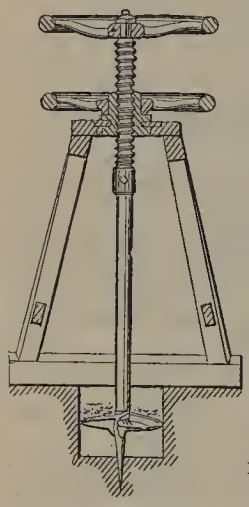
The perforating-machine, for partially dividing the postage-stamps in the sheet, was invented by Mr. Archer of England, 1852, and he received £4,000 from Parliament for his invention.

Rowland Hill's penny-postage scheme was adopted January 10, 1840. The number of letters mailed in England rose from 76,000,000 in 1838 to 642,000,000 in 1863. The gross returns rose from £2,346,000 to £3,870,000; the profits from £1,660,000 to £1,790,000.

Post and Stall. (*Mining.*) A mode of working coal in which so much is left as pillar and so much is worked away, forming *rooms* and *thurlings*. *Pillars* and *rooms*.

Post-au'ger. An earth-auger for boring post-holes. Fig. 3907 has a screw shaft provided with a point and auger at the bottom, and a wheel at the top which rotates in a nut and feeds the auger into the ground. On retracting the auger the shaft remains stationary and the nut is rotated. See also AUGER; EARTH-AUGER.

Fig. 3907.



Post-Auger.

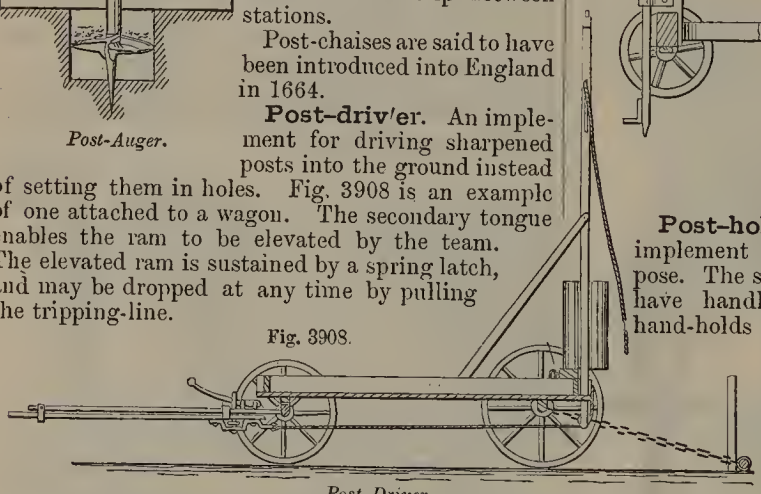
Post-butt. A block inserted in the ground and having a socket to hold a post.

Post-chaise. A closed vehicle for hire, designed to be drawn by relays of horses, hired for each trip between stations.

Post-chaises are said to have been introduced into England in 1664.

Post-driv'er. An implement for driving sharpened posts into the ground instead of setting them in holes. Fig. 3908 is an example of one attached to a wagon. The secondary tongue enables the ram to be elevated by the team. The elevated ram is sustained by a spring latch, and may be dropped at any time by pulling the tripping-line.

Fig. 3908.



Post-Driver.

Fig. 3909 is attached to a sled. A weight is operated within the frame by means of an adjustable hook and rope.

Post'er. A printed sheet to be attached to a wall or boarding, as an advertisement.

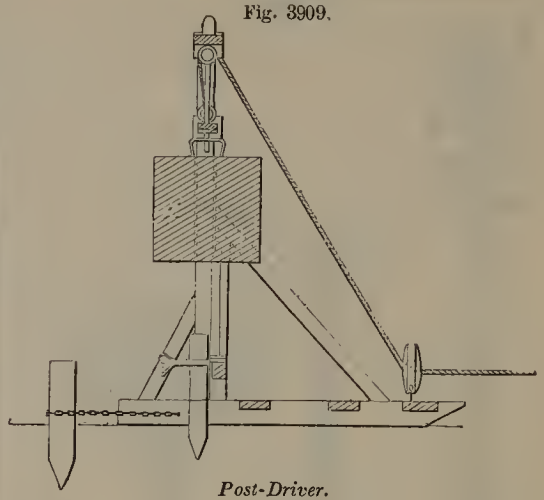
Pos'tern. 1. (*Fortification.*) *a.* A vaulted passage underneath a rampart, leading from the interior to the ditch and closed by a gate.

b. A passage-way at a retired part of a bastion.

2. A small doorway or gateway at the back of a building.

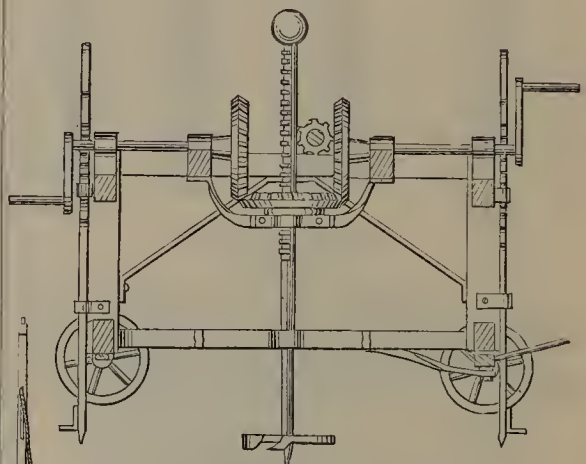
Post-hole Bor'er. An implement for boring holes for fence-posts. In the example, the square shaft of the auger is turned by a bevel-wheel through which it slides, and has a rack into which the spur-wheel is meshed when the earth is to be raised. The wheel is rotated by a hand-crank.

Fig. 3909.



Post-Driver.

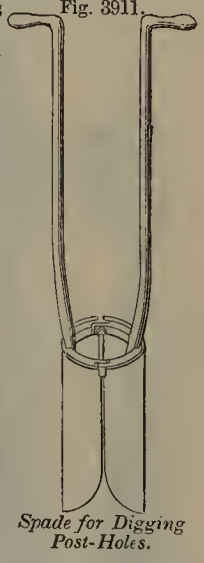
Fig. 3910.



Post-Hole Borer.

Post-hole Dig'ger. Fig. 3911 is a hand implement for this purpose. The segmental spades have handles with radial hand-holds by which they may be turned or oscillated to cut a cylinder of earth, which is withdrawn with the spade. They are so pivoted as to admit of flaring to form an undercut hole. See EARTH-AUGER.

Fig. 3911.



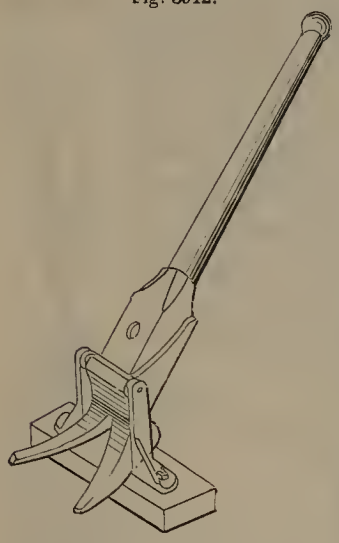
Spade for Digging Post-Holes.

Post-hook. (*Harness.*) A check-rein hook, having an ornamental post extending up above the opening for the rein.

Post-horn. (*Music.*) A small horn for stages and canal-boats, to sound an alarm for relay of horses, notice to keepers of canal-locks, etc. See HORN.

Post-jack. An implement for lifting posts out of the ground. It is a crow-bar pivoted in a base piece and having a claw which catches against the post.

Fig. 3912.



Post-Puller.

Post-mill. An old form of windmill which was mounted on a post. The post was continued through several stories, and formed the axis on which the mill vcered as the wind changed.

Post-mor'tem Case. A small pocket-case of instruments in which the box, like a knife-handle, is made the receptacle for the necessary tools, a small saw, scalpels, bone-chisels, needles, and a tool-handle.

Other cases are made larger, but the above is designed to avoid notice on the part of the relatives in cases of autopsy.

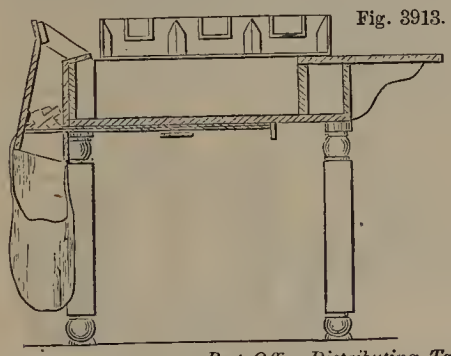
Post-of'fice Box. 1. A case or a locked box into which the letters of a person or firm are distributed, so that they can be handed thence by an official or taken thence by the owner by opening a door at the other end from the distributor.

2. A series of pigeon-holes into which letters for a given destination or mail-bag are distributed at the receiving station or in a postal car.

Fig. 3913 is a table for the distribution of mail matter, having a series of boxes at its edges, with hooks upon them for the attachment of bags. The sides presented to the operator have racks to hold cards of designation.

3. A box at a post-office or convenient place in a street, on a lamp-post or otherwise, to receive letters to be gathered by the carrier.

Fig. 3913.



Post-Office Distributing-Table.

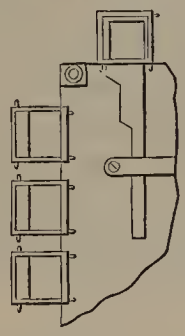
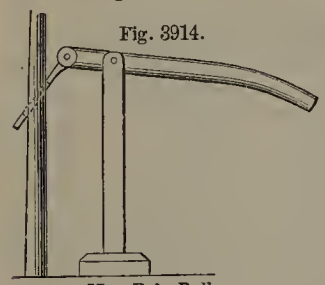


Fig. 3914.



Hop-Pole Puller.

Post-pull'er. An implement to pull posts out of the ground. Fig. 3914 is one form in which a lever pivoted to a post has a shackle on its end which grips and lifts the hop-pole.

Post-tab'u-la. (*Architecture.*) The wall or screen at the back of an altar. *Retro-tabula; reredos.*

Pot. 1. (*Sugar.*) A perforated hogshead in which crude sugar is placed for drainage of the molasses.

2. (*Tinning.*) *a.* A vessel filled with melted tallow in which the charcoal-iron plates are dipped before tinning. *Grease-pot.*

b. A bath used in the same work, known as a *wash-pot.*

3. (*Founding.*) A brass-founder's name for a crucible. Graphite pots are most generally in use.

Po'tance. (*Watchmaking.*) The stud which forms a step for the lower pivot of a verge.

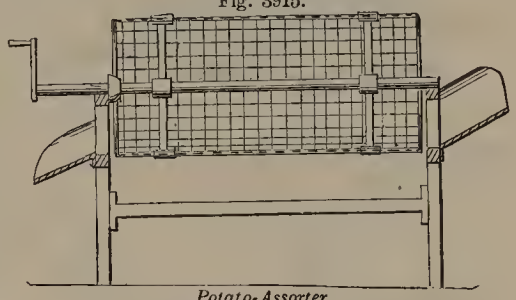
Po'tance-file. A small hand-file with parallel and flat sides.

Po-tas'si-um. Equivalent, 39.2; symbol, *K* (kalium); specific gravity, 0.865; fusing-point, 136° Fah. This metallic base of the alkali potassa was discovered by Sir Humphry Davy in 1807. It is a brilliant, silver-white metal, tarnishes immediately on exposure to the atmosphere; is soft at ordinary temperatures, brittle at 32° Fah. Its affinity for oxygen is so energetic that water is decomposed by contact, the liberated hydrogen being inflamed.

The salts of potash are very useful in the arts, as ingredients in glazes for pottery, fluxes in glass, in soap-making, washing, gunpowder, etc., etc.

Po-ta'to-as-sort'er. A rolling screen with open meshes to allow small potatoes to be sorted from the larger merchantable ones.

Fig. 3915.



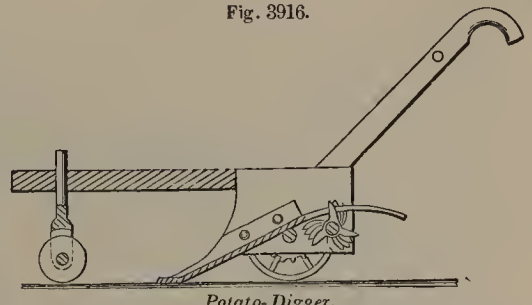
Potato-Assorter.

Po-ta'to-bug Clean'er. An implement to travel down the rows of plants and beat off the bugs into a tray, in which they are collected and killed.

Po-ta'to-dig'ger. (*Husbandry.*) An implement for digging potatoes from the row or hills, and depositing them on the surface of the ground or in a box on the machine.

Fig. 3916 is supported on a wheel, and has a grating or bars which lift the tubers, sift the earth from among them, and drop them on the surface of the ground.

Fig. 3916.

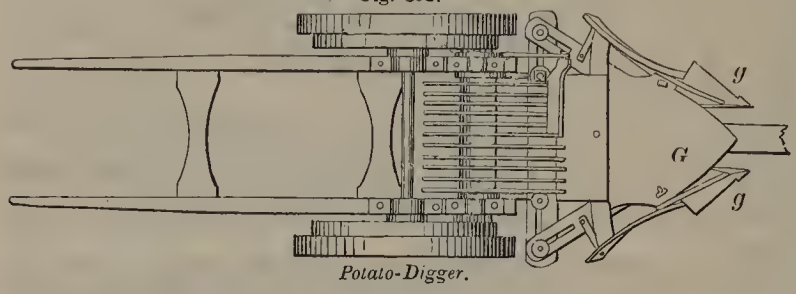


Potato-Digger.

Fig. 3917 is a more complicated implement, which has a pair of side plows *g g*, a middle plow *G* with a large wide share which slips under the hill of tubers and lifts them; they are then pushed back on the grating, which allows the dirt to fall through, and the tubers drop off the end of the grating.

In Fig. 3918, the potatoes, after lifting, are carried over the longitudinally barred screen, and then divested of the earth upon the rotating-screen. The cams near the fore end regulate

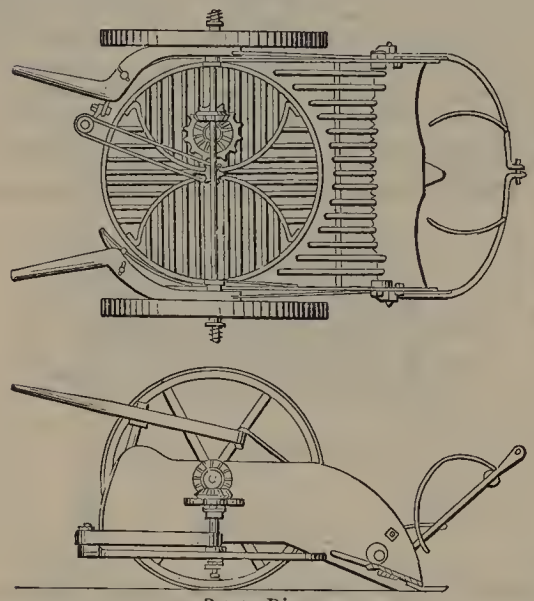
Fig. 3917



Potato-Digger.

the inclination of the scraper at the fore end of the fixed screen.

Fig. 3918.



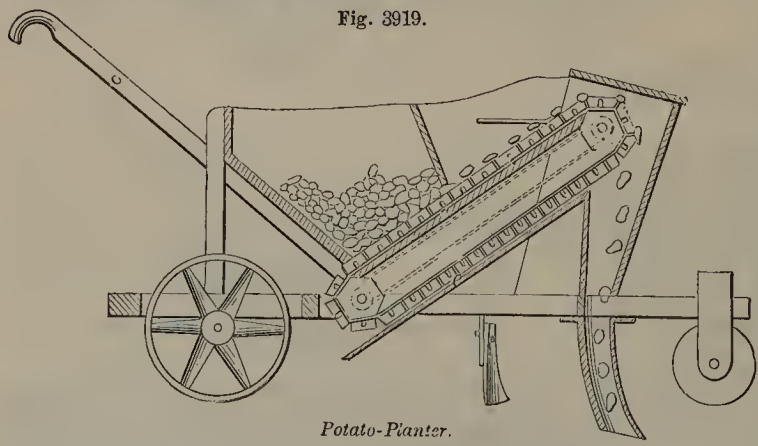
Potato-Digger.

Po-ta'to-hook. (*Husbandry.*) An implement with bent tines, used in digging potatoes.

Po-ta'to-mash'er. (*Domestic.*) A kitchen implement for mashing cooked potatoes. It is often a mere wooden pounder, but may also be made of wire. In the example (Fig. 3920), the lower face of the masher consists of a coil, and it is attached to the handle by ribs.

Po-ta'to-plant'er. (*Husbandry.*) An implement for dropping potatoes into a furrow and covering them. There are many kinds. The example has an endless traversing belt with a series of pockets which pass under a striker to remove superfluous

Fig. 3919.



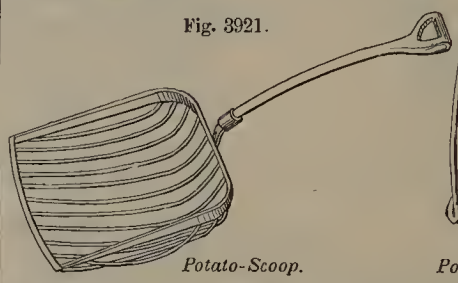
Potato-Planter.

sets, and open to drop their sets into the planting share, which precedes the covering shares and the roller, which acts as a driving-wheel.

Po-ta'to-scoop. (*Husbandry.*) A grated shovel which allows the soil to sift through while detaining the potatoes. The iron rods or wires are placed

Fig. 3920.

Fig. 3921.



Potato-Scoop. *Potato-Masher.*

at equal distances on an iron frame, which is attached to a wooden handle and acts as a screen in shoveling potatoes or other roots.

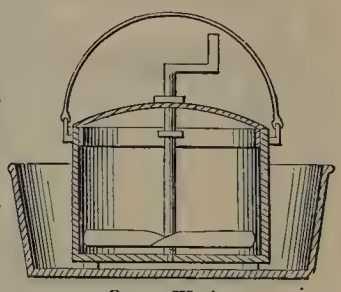
Po-ta'to-sep'a-ra'tor. An implement used for the purpose of sorting the tubers in sizes; for feed, market, seed, etc.

One form consists of three screens with meshes of different sizes, spouts conducting to separate receptacles the tubers detained by each screen.

Another form is a revolving drum, which has different sized meshes at different parts of its length.

Po-ta'to-wash'er. For washing potatoes in large quantity for feed or starch-making, they are placed in a slatted cylinder which is rotated by a hand-crank, the axis being supported on the ends of a trough of water. The friction of the potatoes on each other and against the slats of the cylinder cleans the dirt from them.

Fig. 3922.



Potato-Washer.

The example is one on a small scale for kitchen use. The tubers are stirred round and round by the arms on the revolving shaft.

Potch'er-en'gine. (*Paper-making.*) A machine in which washed rags are intimately mixed with a bleaching solution of chloride of lime, after which they are allowed to steep in bins, from which the liquor is drawn off when the bleaching process is completed.

Pot-eye. (*Spinning.*) A guide-eye for a yarn in a spinning-frame. Through it the yarn passes from the rollers to the flyer. Made of metal, glass, or porcelain.

Pot-gun. A mortar for firing salutes. The name is derived from its shape.

Pot-hook. An S-shaped hook for suspendinga culinary vessel from a chimney-crane.

Po'ti-cho-ma'ni-a. Glass-ware coated with paper or linen flowers and varnished, in imitation of old China.

Pot-lid Valve. 1. A cap-formed valve which shuts down like a cover upon a port or the end of a pipe.

2. The cover of the air-pump of a steam-engine.

Pot-met'al. 1. A cheap alloy for faucets, etc. : copper, 10 ; lead, 6 to 8.

2. A grade of cast-iron suitable for casting hollow ware.

3. A species of stained glass, the colors of which are incorporated with the glass while the latter is in a state of fusion in the *pot*.

Pott. An English size of writing-paper, the smallest measuring $15\frac{1}{2} \times 12\frac{1}{2}$ inches, and weighing 10 pounds to the ream.

Pot'ter's Lathe. (*Pottery.*) The revolving disk on which the potter whirls the clay while he shapes it with his hand and with tools. A *whirling-table ; jigger ; thrower ; throwing-machine.*

A sharp tool is employed, which at once turns off and polishes the surface of the work. The band-wheel is turned by means of a winch.

In large potteries, where steam-power is employed, cone-pulleys are applied to the lathe, which impart motion to the shaft (*b*, Fig. 3923) through the medium of bevel-gearing, the speed being varied to correspond with the demands of the work.

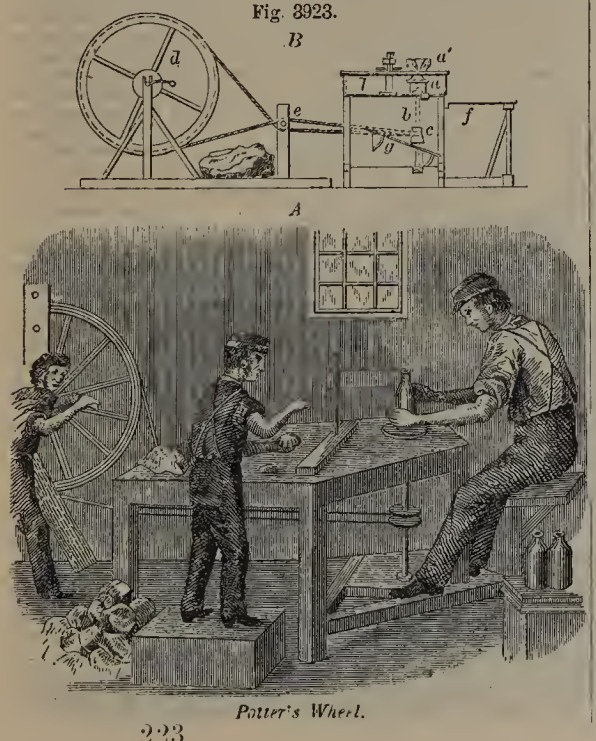
The potter's lathe is also known as a *throwing-machine* or a *jigger*. See POTTER'S WHEEL.

Pot'ter's Wheel. A horizontally revolving disk (*A*, Fig. 3923) driven by a treadle or by an assistant. The lump of clay, being placed upon it, is molded into form by pressure on the inside and outside, properly applied, the circular form being maintained by the passage of the clay between the hands, assisted by a piece of horn or shell, which is called a "rib," and acts as a former, straight-edge, or scraper, as the case may be. (See POTTERY.) Also known as a *jigger, thrower, thrower's engine, thrower's wheel.*

No wheel was used in the construction of the pottery found in the ancient British tumuli. The same is stated by Mr. Bateman of the ceramic remains in the Romau tumuli. The latter seldom have handles, are destitute of spouts, and the ornaments are straight lines, dots, or marks made by cords.

The potter's wheel was also unknown in the ancient pottery of the North American tumuli. Some of the jars of the "Stone age" show that a kind of templet has been used inside, held by one hand, probably against the pressure of the other hand on the outside.

Fig. 3923.



Potter's Wheel.

After it has been roughly fashioned on the *wheel* and allowed to become partially dry, the work is finished on the lathe *B*, which is merely the *wheel* somewhat modified and refined. *a* is the head, carrying a disk upon which the mass of clay *a'* is placed, and turned by the shaft *b*, which carries a set of grooved pulleys *c*, of different diameters, driven by a belt from the band-wheel *d* ; *e* is a guide-pulley which converts the vertical motion of the band so as to cause the horizontal revolution of the pulley *c* ; *f* is a seat on which the workman sits astride, placing his feet on the treadle *g*. The lower figure shows adjustable rods serving as a gage for the guidance of the workman ; *l* a ledge-board for receiving the clay shavings.

Pot'ter-y. Earthenware glazed and baked.

Clay possesses the property of plasticity ; that is, when moistened, it yields to pressure in any direction without breaking, and when the pressure is removed retains the form imparted. If dried at a moderate heat and then crumbled by pressure, it may be again kneaded, and resume its plasticity ; but if baked at a red heat, it acquires a hardness beyond that acquired by mere drying, and if crumbled after baking, can never again become plastic by incorporation with water.

Clay unmixed contracts in drying, exfoliates, and falls to pieces. Sand corrects this, and when introduced within given proportions does not impair the elasticity. Natural clays have almost always more or less lime, magnesia, iron, and salt, which complicate the conditions, as they act as fluxes and confer color upon the ware. Iron alone gives a red color ; iron and lime, cream-brown. The presence of magnesia in addition to the others gives a brownish yellow. The presence of carbonates is sometimes indicated by holes in the ware, produced by carbonic acid, which escapes in the form of gas. Another effect of the lime is to combine with the alumina and prevent its contraction. At a more intense heat the ingredients assume a nearly vitreous condition, and the oxide of iron assumes a bluish or greenish color. The salt is also decomposed, and its base assists the lime. The magnesia may combine with sulphuric acid derived from pyrites in the clay or sulphur in the coal, and is seen in efflorescence on the inside of the kiln.

The Egyptian modes of working the clay, and turning, baking, and polishing the jars, are shown in the tombs of Beni Hassan and Thebes. The clay was kneaded by the feet ; formed into clots of a proper size by hand, and placed on the wheel, which was of very simple construction and turned by hand. The handles, as with us, were separately made and subsequently attached. The required ornament was traced on them while soft ; they were then dried or baked by the escaping heat from the ovens.

The accompanying cut is from a tomb at Beni Hassan, time of Osirtasen or thereabout, 1706 B. C. The aim of the artist was to depict the successive manipulations. Four of the figures are represented working at separate wheels. One forms the inside and lip of the cup as it revolves with the table, holding his thumb dexterously inside against the modified resisting pressure of the left hand. The next man is forming the outside and cutting the cup off at its base, which is not at the bottom of the lump. This is now done by a wire. The third represents another stage of the process, the cup being removed and held aloft in the hand. The fourth man dabs on a new lump of clay, and this completes the series. Cups in various places indicate the character of the manufacture in progress. In the next place, we see a man forming a circular slab of clay. The next is raking the fire. Then follows a man handing a cup to another, who places it on the grate above the opening in the furnace-top, where it is baked. The next man carries off the baked cups in baskets supported on the yoke, which was universally used for carrying.

The date of these paintings entirely upsets the statements of Pliny, who attributes the invention of the potter's wheel to Chorœbus the Athenian, or Anacharisis the Scythian. These paintings were made and the tombs closed on the mortal dust of their occupants 200 years before Cecrops.

On the walls of the tombs of ancient Egypt are painted Ptah the Creator aud Neph the Divine Spirit sitting at the potter's wheel turning clay to form meu. See PORCELAIN.

"As wheu, before his wheel
Seatcd, the potter twirls it with both hands," etc.
HOMER, *Iliad*, XIII. 5.

The pottery of Samos was famous in the time of Homer.

Vases of many beautiful shapes, with single and double handles and very gorgeously colored, are shown in the magnificent French work, "Description de l'Egypte, par les Ordres de sa Majesté l'Empereur Napoleon le Grand." The work is in the Congressional Library in Washington, and the illustrations are on Plate 92, Vol. II., in the portion of the volume treating of the Antiquities of Thebes.

Fig. 3924.

Egyptian Pottery (from Beni Hassan).

The Egyptian pottery in the Metropolitan Museum, New York, includes a specimen asserted to be the oldest piece of glazed pottery with fixable date extant; it is an elongated bead, covered with glass glaze, and assigned to the period of Amon'm'he III., fifth king of the XIIth Dynasty, at a date of about 2020 B. C. This vitreous enamel, almost choking the finer lines of the model, is seen in blue and other colors on many of the little sacred images derived from tombs, and on many of the bead necklaces and ornaments accompanying mummies in the same collection.

"On the clay tablets which we have found at Nineveh, and which are now to be counted by thousands, there are explanatory treatises on almost every subject under the sun: the art of writing, grammars, and dictionaries, notation, weights, and measures, divisions of time, cbronology, astronomy, geography, history, mythology, geology, botany, etc. In fact, we have now at our disposal a perfect cyclopædia of Assyrian science."—SIR HENRY RAWLINSON, 1853.

"Offspring of clay and furnace bright,
The choicest pottery clear aud light,
Boasts, as its birthplace, of tbe towers
Which Neptune's and Minerva's powers
From ills and dangers shield;
Which beat back war's barbaric wave
When Mede and Persian found a grave
On Marathon's undying field."
CRITIAS; quoted by ATHENÆUS, A. D. 220.

The chronicler of the "Deipnosopbists" goes on to say:—

"And indeed the pottery of Attica is deservedly praiscd. But Eubulus says: 'Cnidian pots, Sicilian platters, and Megarian jars.'"

Perhaps no other art has done so much as the ceramic to preserve to us the appearance and habits of the peoples of the past. What with domestic, decorative, and funereal urns and lachrymatories, there are but few nations, it would seem, but have left traces to help us to some conception of their tastes and their capacities. The Metropolitan Museum of New York has a great collection, made by General Di Cesnola, United States Consul at Cyprus See the following works: Marryat's "History of Pottery and Porcelain," London, 1857; Burty's "Chefs-d'Œuvre of the Industrial Arts," Appleton & Co, 1869; "Life of Josiah Wedgwood," London, 1865.

The earthenware of the Greeks and Romans was unglazed, but they covered their pottery with wax, tallow, bitumen, and perhaps other articles, to render them impervious to water, wine, etc. The Romans used molds for ornamenting clay vessels and for making figures of idols, or of limbs, plants, etc., for votive offerings. The Peruvians use tallow, which is spread on while the ware is hot, and becomes partially carbonized. The Etruscan ware has a similar appearance. In Italy and Spain, ancient and modern, wine-jars are rubbed with wax to render them impervious to liquids.

The art of making glazed pottery originated with the Chinese, and passed from thence to India, and from thence successively to Arabia, Spain, Italy, Holland.

In the Alhambra of Granada some of the rooms are ornamented with glazed tiles. The tomb of Sultan Mahoumed Khoda-Bendeb, at Sultanieh in Persia, was built in the thirteenth century, and has green enameled tiles ou the outside aud blue within. The painted mosque of Gour, in India, built in 1475, derives its name from the number of glazed tiles with which it is ornamented. The Caravanserai of Mayar, near Ispahan, built by the mother of Shah Abbas, about 1550, has a coveriug of green glazed tiles on the front of the principal gateway. See TILE.

The material of which the Peruvian pottery was made was a colored earth and blackish clay, well tempered evidently, but apparently without glaze. Singular designs were embodied in their religious and sepulchral vases, which were destined to receive the *chicha* on sacrifice days. The long throat formed the handle, and a second opening admitted or demitted the air when emptying or filling. They were made double, treble, or quadruple; were engraved, painted, and ornamented in relief.

Of all tbe Polynesians, the Feejees alone had the art of making pottery. They did not have the wheel, but the women artificers made graceful and beautiful forms. Their tools were a small flat stone to form the inside, and a spatula for the outer surface. With these tools they made articles almost as perfect as lathe-formed ware.

Dr. Livingstone admired the skill in making pottery evinced by the tribes encountered in his "Expeditiou to the Zambesi."

The town of Delft, in Holland, became celebrated for the manufacture of earthenware, which is held to have been equal in quality to its Italian progenitor, but inferior in its ornamentation, apparently vying with China in its peculiar and almost grotesque modes of representing natural objects. See PORCELAIN.

The potteries of Lambeth, London, were started by men from Hollaud, about 1640.

The potteries of Staffordshire soon took the preëminence.

John Wedgwood was born at Burslem, England, in 1730, and after a variety of experiences such as would sadden and kill an average man, started a pottery on his own account, where he improved the productions of his art. In his second manufactory he established the white stone-ware, and in the third the cream-colored ware which gave him so much celebrity. He also originated a *terra-cotta* which could be made to resemble porphyry, granite, Egyptian pebble, and other stones of the siliceous or crystalliue kind; a black porcelainous biscuit called basaltes; a white and cane-colored porcelain biscuit, smooth and wax-like; and another white porcelainous biscuit, which receives color from metallic oxides like glass on enamel, in fusion.

This property renders it applicable to the production of cameos, and all subjects required to be shown in bas-relief, as the ground can be made of any color, while the raised figures are those of the purest white. He likewise invented a porcelain biscuit nearly as hard as agate, which will resist the action of almost all corrosive substances, and is consequently well adapted for mortars in the chemist's laboratory.

While honoring the names of those who have distinguished themselves in making pottery an art, we must remember Charles Avisseau (born, 1796) the potter of Tours, the city celebrated for the great victory gained by Charles Martel over the Saraceus, October 10, 732,—a victory which, under God, determined the language, religion, and the form of civilization of Europe. Palissy had died three centuries before, the secret of his process dying with him, and Avisseau set about rediscovering the lost art. He succeeded in firing the wares without their undergoing any change and without the use of white glaze. He also composed a series of colors, all fusible at the same temperature, and also a gold enamel. He refused offers to devote his talents to the national establishment of Sèvres, preferring to maiutain his independence and devote himself to a life of experiments and labor at his humble home in Tours.

The materials chiefly used in the North Staffordshire potteries are a light brown clay from Poole in Dorsetshire, and white clay from Cornwall, to which pulverized flint or granite is frequently added. The clays are derived from decomposed granite, and are prepared by mixing them in a *plunger* containing a large wheel, by which they are, with the addition of water, converted into a mass of the consistency of cream. This is run off into small reservoirs. termed *arks*, whence it is pumped up and passed through a series of sieves, by which it is reduced to *slip*. This is forced, under a pressure of 80 pounds to the square inch, into *chambers*, shallow pans over which are placed linen covers, in which the slip is received, permitting the escape of the expelled moisture and leaving it of a doughy consistency. It is then passed through a *pug*, a chamber having a spiral revolving blade, where it is hardened and compressed, and after being formed into large square cakes is placed in a dark cellar, where it undergoes the process of fermentation.

From these blocks are formed *stilts* and *spurs*, used for supporting pieces of pottery and porcelain in the drying-stoves. The blocks are placed in a rectangular chamber having a piston by which the clay is forced out through apertures of square, round, triangular, or other form adapted to the machine employed in the succeeding process. The flat pieces are called *backs;* the others, *shapes*. These are cut by a guillotine-like instrument into proper lengths, and then stamped by means of

leaden dies in a press, by which a large number are formed at each impression.

The *stilts* or *spurs* are generally of triangular form, and have sharp projecting points. They are now placed in oval *saggars*, made of marl, which are inserted in a furnace and exposed to an intense heat for forty hours.

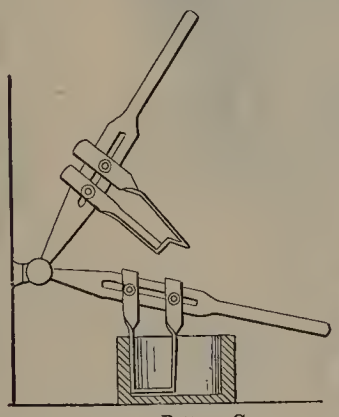
Common door-knobs, furniture casters, telegraph insulators, and similar articles are turned in the usual manner, while lock furniture of colored porcelain is stamped in dies from the dry clay-dust; these are then baked and dipped in glaze, which is afterward melted in ovens.

Pot'ter-y and Clay. See also under the following heads: —

Arch-brick.
Bags.
Bat-printing.
Batter.
Batting-block.
Biscuit.
Bisque.
Blowing-pot.
Blunging.
Bossing.
Böttger-ware.
Brick.
Brick-clamp.
Brick-dryer.
Brick-kiln.
Brick-machine.
Brick-mold.
Brick-press.
Brown-ware.
Bung.
Casting clay-ware.
Chimney-pot.
China.
Churn.
Clamp.
Clapper.
Clay-mill.
Clay-pipe.
Clay-pulverizer.
Clay-screening machine.
Clinker.
Cockle.
Cockspur.
Compass-brick.
Concave-brick.
Concrete-pipe.
Crazing.
Crockery-ware.
Crucible.
Crucible-mold.
Crucible-oven.
Cutter.
Delft.
Dod.
Draining-pipe.
Dressing-bench.
Earthen-pipe.
Earthenware.
Email-cmbrant.
Enamel-kiln.
Encaustic tile.
Faïence.
Fat-lute.
Fire-brick.
Flint-mill.
Float-stone.
Fusible porcelain.
Gaged brick.
Gilding porcelain.
Glaze
Glaze-kiln.
Glost-oven.
Green-house.
Grinding-vat.
Grouud-laying
Hack.
Hack-barrow.
Hake.
Hardening-kiln.
Hard porcelain.
Hip-tile.
Hot-house.
Hovel.
Ironstone-china.
Jigger.
Kaolin.
Later.
Lath-brick.
Lawn.
Luster-ware.
Lute.
Majolica-ware.
Malm-brick.
Marle-stock.
Milling.
Molding.
Molding-tile.
Mosaic tile.
Oveu.
Page.
Pallet.
Parian.
Pavior.
Pipe-molding.
Plunger.
Polished brick.
Porcelain.
Porcelain-gildiug.
Porcelain-uill.
Porcelain-printing.
Potter's lathe.
Pottery.
Pottery-gage.
Pottery-kiln.
Pottery-molding.
Pottery-painting.
Pottery-printing.
Pottery-tissue.
Pressed brick.
Press-printiug.
Pug-mill.
Refractory.
Re-pressing machine.
Saggar.
Setter.
Sèvres porcelain.
Slapping.
Slicing-machine.
Slip.
Slip-kiln.
Slop-molding.
Smearing
Spattle.
Splayer.
Stamper.
Stilt.
Stock-board.
Stone-ware.
Strickle.
Strike.
Tempering-wheel.
Tender-porcelain.
Terra-cotta.
Tessellated tile.
Tesseræ.
Thrower.
Throwing-engine.
Thwacking-frame.
Tile.
Tile. Encaustic
Tile-kiln.
Tile-laying plow.
Tile-machine.
Tournasin.
Triangle
Turning.
Ventilating bricks.
Watch.
Wedging.
Wedgwood-ware.
Whirling-table.
Wormiug-pot.

Pot'ter-y-gage. A shaper or templet for the inside of a vessel on the wheel. It is designed to finish the inside of stone-ware smoothly and of a uniform size.

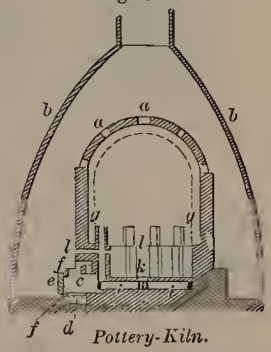
Fig. 3925.



Pottery-Gage.

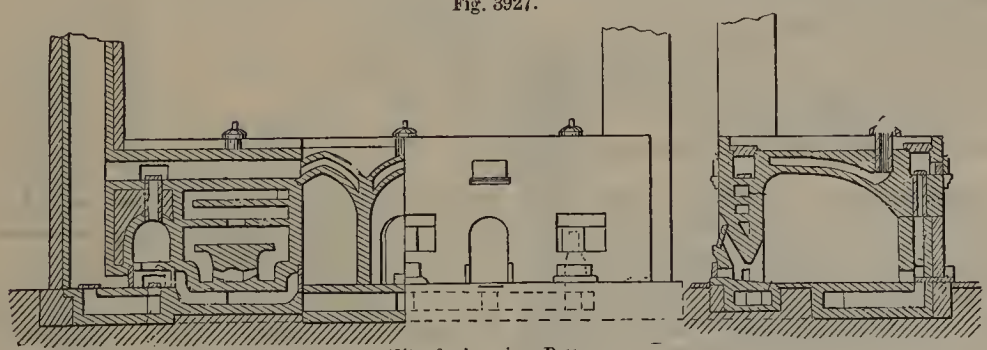
Pot'ter-y-kiln. The pottery-kiln, shown in section (Fig. 3926), consists of a cylinder of brick-work surrounded by iron bands and having a hemispherical top with apertures *a a* for the escape of smoke. It is surrounded by a cover *b*, which protects it from the cooling effects of air and rain, and has a chimney. Six or eight fireplaces are arranged equidistantly around the cylinder. *c* is the grate of one of these fireplaces; *d*, the ash-pit; *e*, the door; *f f*, draft-openings; between the furnace wall and the chimneys *g g* is an annular space about 15 inches wide, elevated about 3½ feet

Fig. 3926.



Pottery-Kiln.

Fig. 3927.



Kiln for burning Pottery.

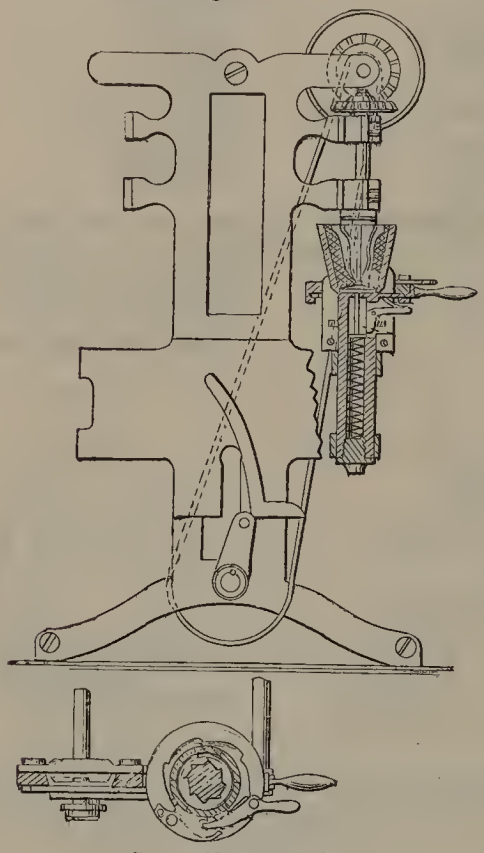
above the floor, below which are flues *i i* for the circulation of flame, all meeting at the center *k*. *l l* are sight-holes, enabling the workmen to see the interior of the kiln, that they may watch the action of the fire and regulate the draft accordingly.

In Fig. 3927, the gases and products of combustion pass off through the doorways or double walls and openings connected with the lower flue, a top flue connecting the space between them by means of tubes for carrying off the vapor of the green material,

there being a double arch for heating the air on its way to the fireplace and returning it. A bottom flue also communicates with the kilns and smoke-stacks, to prevent the loss of heat and drawing up of moisture in the kiln. The views are a partial longitudinal section and elevation, and a transverse section.

Pot'ter-y-mold'ing. A machine for shaping articles of plastic clay. The flask is attached to a

Fig. 3928.



Pottery-Molding Machine.

vertically sliding frame, and its charge is brought into contact with a revolving core. The flask is composed of a series of sections, which can be opened to remove the pot after molding. The bottom of the flask is also movable, and is pressed up to facilitate the removal of the molded pot.

Pot'ter-y-paint'ing. In this art enamel colors are used, such as will withstand the fire unchanged or will develop their colors under heat. Various metallic oxides are used for this purpose. See ENAMEL.

Painted porcelain is fired in a muffle-furnace.

Pot'ter-y-print'ing. (*Pottery.*) The device for the plate or other article is engraved on copper or otherwise, and an impression taken on a piece of unsized paper. This is wetted and placed over the plate, which is in the biscuit condition. The ink adheres to the plate when the paper is removed.

Another plan is to take an impression in oil only, and then dust the color on to the plate, to which it only adheres in the parts covered with oil.

The surface of the printed ware is covered with glaze, the ware placed in a *saggar* and burnt in a kiln.

Pot'ter-y-tis'sue. A kind of tissue-paper used to receive impressions of engravings for transference to *biscuit*. See PRESS-PRINTING.

The paper is made on the Fourdrinier machine in lengths sometimes equal to 1,200 yards.

Pot'ting. The cleansing of sugar by placing it while soft in inverted conical molds with a mass of saturated clay on top.

Placing new sugar in barrels to drain.

Pot'ting-cask. (*Sugar.*) A hogshead with holes in the bottom into which imperfectly crystallized sugar is dipped in order that the molasses may drain from it. In each hole is placed a crushed stalk of cane or plantain, which reaches to the top of the sugar. The molasses passes off through the spongy stalk, leaving the sugar comparatively dry and more perfectly crystallized.

Pot-wheel. A form of water-raising wheel. See NORIA.

Pouch. 1. A bag, usually leathern, for mail matter, money, or ammunition.

2. A cartridge-box.

Pou-de-soy; Pad'e-soy; Pod'de-soy. (*Fabric.*) A rich plain silk.

Pou-lon'. (*Fabric.*) A close woolen Thibetan stuff.

Poul'tice-boot. (*Menage.*) A large boot used for applying poultices to horses' legs. It is made of soft leather for the sides and a heavy sole-leather bottom.

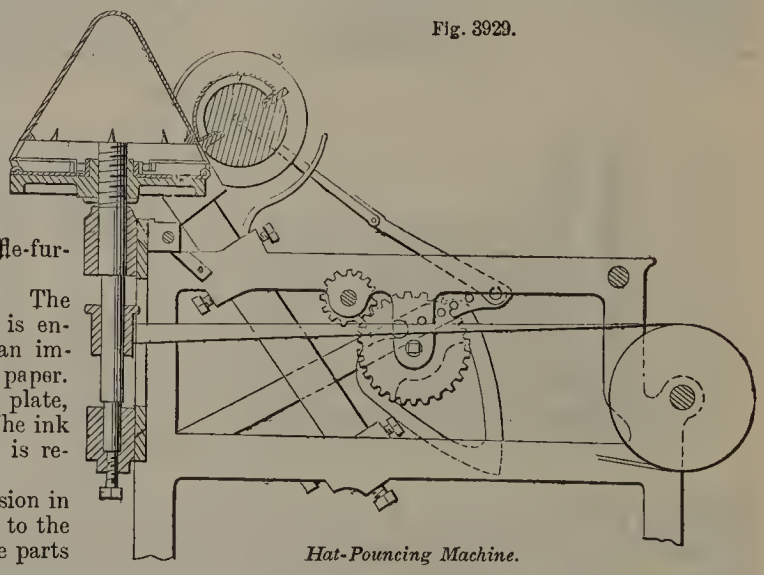
Poul'try-feed'er. A device to feed grain to fowls in quantity as used. It is upon the principle of the fountain-inkstand or the water-bottle for bird-cages, grain falling down into the trough as the latter is emptied.

Pounce. Pounded gum-sandarach and cuttle-fish bones. Used on freshly written manuscript instead of blotting-paper.

Pounce-pa'per. A tracing-paper prepared at Carlsruhe without oil.

Pounc'ing-ma-chine'. (*Hat-making.*) A machine for raising a nap upon hat-bodies by a grinding action. In Fig. 3929, the sand-paper or other rubbing surface has a rising or falling motion in an inclined direction, so as to act in a conical form; the *former* revolves on its axis and also traverses to and fro horizontally; it may also be raised and lowered. The india-rubber cushion allows the rubbing surface

Fig. 3929.



Hat-Pouncing Machine.

to yield and thus avoid the wearing of holes in the

hat-body where inequalities exist. By turning a disk on its axis it rises and falls upon the screw-thread thereon, and so loosens or tightens the hat-body secured to the hooks in another disk ; the latter resting upon and rising and falling with the first-named disk, but not turning with it.

Pound. 1. The avoirdupois pound of the United States equals 27.7015 cubic inches distilled water at 62° Fah., barometer at 30 inches, and the water weighed with brass weights in the air. This equals 7,000 grains, and is divided into 16 ounces, each ounce into 16 drams.

The troy pound has 5,760 grains, divided into 12 ounces, each ounce into 20 pennyweights, each pennyweight containing 24 grains.

The pound apothecary's weight is the same as the pound troy, but the ounces are divided into 8 drams, each dram into 3 scruples of 20 grains each.

One hundred and forty-four pounds avoirdupois equals 175 pounds troy or apothecary's weight.

The old Saxon pound sterling was a pound of silver troy weight.

2. (*Hydraulic Engineering.*) The level space of a canal between locks.

Pound'er. 1. The *beater* in a fulling-mill.

2. A *stamp* in an ore-mill.

3. The expression of a weight in shot, as 18-pounder, 24-pounder ; usually written, 18-pdr., 24-pdr.

Pound'ing-ma-chine'. (*Metal.*) A stamping-mill. The term is usually applied to a powder-mill.

Pow'der. A finely comminuted substance. See GUNPOWDER ; POLISHING-POWDER, etc.

Pow'der-blow'er. An instrument for blowing powder on to plants or into crevices infested by insects. See also FUMIGATOR.

Pow'der-chest. (*Nautical.*) A form of grenade consisting of a box charged with powder, old nails, etc., to be hurled at boarders.

Pow'der-flask. A pouch or metallic case for holding gunpowder, and having a charging nozzle at the end.

Pow'der-horn. A horn fitted to hold powder and used as a flask.

Pow'der-hose. (*Blasting.*) A tube of strong linen, about an inch in diameter, filled with powder, and used in firing military mines.

Pow'der-ing-mill. See GRINDING-MILL ; SNUFF-MILL ; ORE, etc. See list under MILL.

Pow'der-mill. Works in which the materials for gunpowder are prepared and compounded and the powder grained and faced. See GUNPOWDER.

Pow'der-mix'er. A pharmaceutical device for intimately mixing various powders. This is usually done on a small scale in a Wedgwood mortar, but in some cases a cylinder with spiral revolving beaters is employed.

Pow'der-prov'er. See BALLISTIC PENDULUM ; EPROUVETTE.

Pow'der-room. (*Nautical.*) The apartment in a ship where powder is kept.

Pow'er. *Force* is the constant pressure. *Work* is the pressure multiplied by the distance through which the force is kept up. *Power* has reference to the *work* performed in a given time. *Duty* is the amount of work performed with a given consumption of material, say of coal, for instance. See DUTY.

Pow'er-ham'mer. A hammer in which the weight is raised by the power of machinery. There are several varieties, which differ in construction or mode of application.

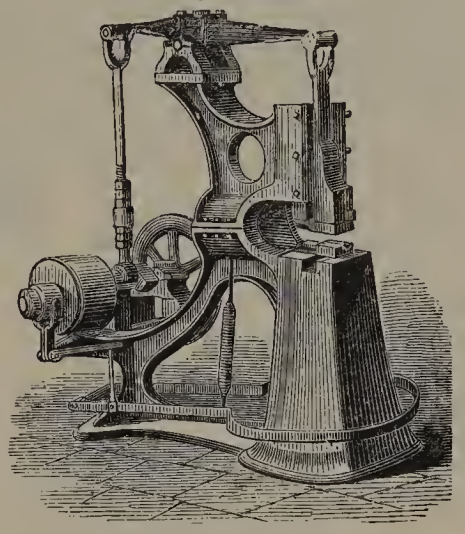
Steam-hammer.	Dead-stroke hammer.
Atmospheric hammer.	Tilt-hammer.
Monkey.	Revolving-hammer, etc.
Pile-driver.	

See list under HAMMER.

Fig. 3930 may stand as an example of a form of power-hammer, made of various sizes from that of heavy forging to the small hammer for jewelers.

The power is communicated by a friction pulley. The belted pulley is loose on the shaft, and the friction pulley slides on a spline on the shaft. The operator bears down with his foot upon the treadle, which passes around the hammer ; this brings the

Fig. 3930.



Palmer Power-Spring-Hammer.

friction in contact with the belted pulley, which is running all the time, and rotates the shaft, on which is a crank ; this, by means of a connecting rod and spring, works the hammer, giving a blow depending for its strength upon the force with which the friction pulley is pressed against the belted pulley.

Pow'er-loom. A loom driven and actuated by machinery ; in contradistinction to a *hand*-loom.

It was invented by Dr. Edmund Cartwright. He patented it April 4, 1785. Steam was applied to his loom in 1807. He received a Parliamentary grant of £10,000 in 1808. He died in 1823, aged 80. See LOOM ; WEAVING.

Poy. (*Nautical.*) A steering-pole.

Poy'al. (*Fabric.*) A striped stuff for covering benches and seats.

Poynt'ell. Paving formed of small lozenges or squares laid diagonally.

Poz'zu-o-la'na. A volcanic earth composed mainly of silica and alumina, and shipped from Pozzuoli. A portion analyzed by M. Berthier was constituted as follows : —

Silica	44.5	Soda	4
Alumina	15	Potash	1.4
Lime	8.8	Water	9.2
Magnesia	4.7		
Oxide of iron	12		99.6

Strabo says of this earth : —

" Puteoli has become a place of extensive commerce, having artificially constructed harbors, which were much facilitated by the facile nature of the sand [degraded tufa], which contains much gypsum, and will cement and consolidate thoroughly. For mixing this sand with limestones they construct moles in the sea, thus forming bays along the open coast in which the largest transport-ships may safely ride."

It was obtained by the Romans near Baiæ, and is still exported largely from that part of Italy. Mixed with lime and water, it hardens anywhere, — in the air or under water. It is invaluable, and the permanency of the great sea-walls and other maritime

structures of the Romans is largely due to its use. It is commonly known as *Roman cement.*

Many attempts have been made to form an artificial pozzuolana by combinations of sand, clay, lime, and iron. Ochreous clays are especially suitable.

General Treussart's system for making artificial pozzuolana is to reduce soft red bricks to powder, and mix them (2 parts) with lime that has been some time slaked (1 part); water to incorporate. See CEMENT.

The preparation of the natural material is by pounding or grinding and sifting, whereby it is reduced to powder, in which state it is beaten to a proper consistency with a due proportion of lime. Artificial pozzuolana is produced by pulverizing the clay, the psammite, or the arene, which is wetted, and then strewing a layer of it, about four tenths of an inch, on a plate of iron heated to a point between a cherry red and forging-heat. It is left till it be raised to the same degree, for a space of time which varies for each kind of material, from five to twenty minutes. It must be continually stirred with a small rod, in order that the whole of the particles may be uniformly calcined.

Hydraulic limes which harden under water are dependent for their quality upon the presence of a certain amount of clay. In France the manufacture of artificial hydraulic lime is largely carried on. See LIME-KILN.

Pra'am. (*Vessel.*) *a.* A flat-bottomed lighter or barge, used in Holland and the Baltic.

b. A floating battery.

Prac'tice-butt. (*Ordnance.*) A target for practicing with guns.

Pra'hu. The war-vessel of the Malays. It is from 55 to 156 feet in length; carries 76 to 96 rowers, and from 40 to 60 fighting men. The guns are of brass, from 2 to 6 inches' bore, mounted on stock pieces, and from 4 to 10 in number. — ADM. SMYTH.

Prai'rie-plow. A large plow supported in front on wheels, and adapted to pare and overturn a very broad but shallow furrow-slice.

Its sharp share cuts at about half the depth of the sod's thickness, and such is found to be more effectual in killing the growth than in turning over the whole sod by cutting at a depth below the growing portions of the sod.

Pray'a. An embanked road or public walk.

Pray'ing-ma-chine'. We have never heard that any of our driving business men have made praying-machines for the Oriental market, although cast-iron gods, bronzed and varnished, have been made by the ton in Birmingham, England, and exported thence to heathen lands.

Praying-machines are in vogue in all the lands which acknowledge Thibet as their religious center. This includes India, Ceylon, Burmah, Siam, China, and Japan. Divided as it is from the mainland of the continent, and superior to China as Japan appears to be, there is much affinity between their forms of civilization and government, and in many details of their manners and religion.

In Thibet the art of praying has been brought to a high state of advancement. It is no longer difficult to utter long prayers, for the prayer written on a piece of paper or a leaf and fastened to a wheel is understood to be uttered once for every revolution of the wheel. The motion of the written is the mechanical equivalent of the vocal exercise. When before an idol, it is understood to be presented toward the god once during each revolution; and the women, who do most of the praying there, saunter into the temple, chat over the news and compare babies, meanwhile turning the wheel diligently. They go down from thence feeling justified and comfortable.

Anon comes one who is struggling in spirit with a great unfulfilled wish, and, flinging herself on the floor, turns the wheel with energy as she utters her prayer for a "bull child," or some other fervent desire of her heart.

A praying-cylinder seen by Dr. Hooker at Simonboug in Sikkim consisted of a leathern cylinder placed upright in a frame; a projecting piece of iron struck a little bell at each revolution, the movement being caused by an elbowed axle and string. Within such cylinders are deposited written prayers, and whoever pulls the string properly is considered to have repeated his prayers as often as the bell rings. The machine is driven in a direction contrary to that of the apparent motion of the sun. This is probably important.

The *barrel* corresponds to the *beads* and *rosaries* of regions farther west. The rosary, in fact, is borrowed from the East.

These mechanical developments of mental emotions are the natural outgrowths of a certain grade of civilization.

In another machine, two small rings are

Fig. 3931.

Praying-Machines.

placed on each spoke of the wheel, the jingling thereby produced being to attract the attention of the god. The greater the noise the greater the certainty of being attended to. The credit for prayers is in proportion to the energy of the action and the number of revolutions.

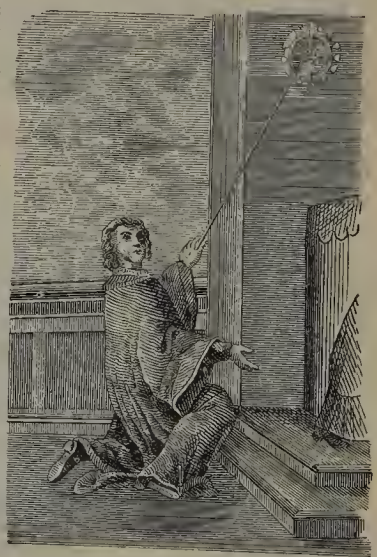
Some of these legends are to invoke the attention of Buddha to the condition of the souls of the departed, the metempsychosis being a form of purgatory; others are aphorisms which are understood to be devout expressions of patience.

> "I would not harshly scorn, lest even there
> I spurned some elements of Christian prayer,—
> An aim, though erring, at a 'world ayont,' —
> Acknowledgment of good, — of man's futility,
> A sense of need and weakness; and, indeed,
> That very thing so many Christians want,—
> Humility."

These mechanical aids to prayer and substitutes for pilgrimage are to be found on roads in Thibet. You see pasteboard barrels, fixed on an axle and inscribed with choice prayers. The devout give the barrel a turn, and it revolves for a long time, according to the perfection of its workmanship, the force of the impulse, and the lubrication of the axle. The barrel prays for the persons, as one traveler remarks, "as long as gravitation and friction will permit. They sometimes fight for the privilege of turning the barrel." The poor fellows at the pool of Bethesda may have done the same in settling the question of precedence.

The words "Om Mani Padmi om" (*Hail to him of the Lotus and the Jewel*) are frequently painted on the cylinders of these machines and prayers placed within. One noticed by Hooker, the naturalist, on a stream in Bhotan, was made to rotate on its axis by a spindle which passed through the floor of the building into the water, where it was terminated by a wheel. Such praying-cylinders are called *mani* by the Lamas.

Fig. 3932.



The Japanese praying-machine is somewhat similar. The proper subjects for prayer are displayed on the pillar, and the wheel in its recess is understood, during each revolution, to repeat the legend on the shaft. This reminds one of the warning, "Use not vain repetitions, as the heathen do."

Sonnettes used in Churches (*Bonanni*, 1776).

Fig. 3932 is a representation from the "Descriptiou des Instrumens Harmoniques, en tous Genre, par le Père Bonauni." Published at Rome, 1776. It is described as "Sonnettes used in churches," having a wheel with small bells on its periphery, and rung by a cord attached to the center of the wheel. Though somewhat indistinct in the original, it appears that the cord is attached to a wrist so as to revolve the wheel. It seems to have been adopted into Christian worship in Bretagne by a woman who renounced the worship of "The Star," but brought along the paraphernalia of the temple, intendiug to sanctify an esteemed and musical observance to the worship of a new object. So the jingling has proceeded for many centuries, from almond-eyed Cathay aud old Zipango to the Bretons and Basques by the ocean of Atlantis.

Pray'ing-mill. A little water-wheel to keep a written prayer moving. Abbé Huc ("Travels in Tartary," 1844–46) refers to what he calls "a kind of *praying-mill*," known to the Tartars as a *chu-kor* or *turning-prayer*. He says: —

"It is common enough to see them fixed in the bed of a running stream, as they are then set in motion by the water, and go on praying night and day, to the special benefit of the person who has placed them there. The Tartars also suspend them over their domestic hearths, that they may be set in motion by the current of cool air from the opening in the tent, aud so twirl for the peace and prosperity of the family. Another machine which the Buddhists make use of to simplify their devotional activity is that of a large barrel turning on an axis. It is made of thick pasteboard, fabricated of inuumerable sheets of paper pasted on one another, and upon which are writteu in Thibetau characters the prayers most in fashion. . . . . The devout can then eat, drink, and sleep at their ease, while the complaisant machine does all their praying for them."

He also relates a fight between two Lamas over a praying-mill which had been set in motion by one, and then stopped and again set in motion by the other. See PRAYING-MACHINE.

Preen. 1. A clothier's forked tool.

2. A bodkin.

Pre-pon'der-ance. (*Ordnance.*) The excess of weight of the part in rear of the trunnions over that in front. It is measured by the weight which requires to be hung to the muzzle to bring the gun to a horizontal line when suspended freely on its trunnions.

The preponderance of a gun is usually $\frac{1}{20}$ of its weight.

Pres'er-va'tion of Food. Various methods may be employed for preventing the fermentation and putrefaction of animal and vegetable substances and maintaining their usefulness as foods.

Cold. Putrefaction is entirely prevented or arrested at temperatures below the freezing-point, and animal substances may be thus preserved for indefinite periods without change. The mammoths found in masses of ice in Siberia were unchanged after the lapse of untold ages.

This method is largely employed during winter in cold climates and on a smaller scale in the keeping or transportation of flesh, game, etc., during the warm season.

Desiccation. This method is applied to both animal and vegetable substances. It is effected by exposing them, after having been sliced or cut into small pieces, to the sun in warm dry weather or to a current of warm dry air at a temperature not exceeding 140° Fah. If this be exceeded, flesh becomes hard and insipid. Vegetables prepared in this way are afterward compressed into a small bulk.

Buccaning consists in drying and smoking meat cut into thin slices. From this practice the West India Buccaneers of the seventeenth century are said to have derived their name.

Jerked beef is prepared by dipping thinly sliced meat into water and afterward drying it in the sun. This is sometimes pounded into a mass and packed in jars.

Pemmican is prepared from buffalo meat, sliced and dried in the sun or before the fire, pounded and mixed with melted fat, to which flavoring herbs or berries are sometimes added.

Flesh not for food may also be preserved by *immersion in antiseptic liquids*, as alcohol, to which camphor, sal ammoniac, or common salt may be added. A weak solution of creosote, sulphurous acid, or of alum, with or without the addition of corrosive sublimate or arsenious acid, may also be employed to prevent putrefaction.

Pickling in vinegar containing $1'_{400}$ of creosote will preserve meat unchanged for a considerable time even during warm weather. The most efficacious mode of applying antiseptics is to inject them into the blood-vessels of an animal when recently killed. Such is Gannal's process, in which a solution of sulphate of alumina or preferably chloride of aluminium is injected into the carotid artery of a slaughtered animal as soon as the flow of blood has ceased, the extremities of the jugular veins having been previously tied. If the meat is to be kept for more than a few weeks, it should be washed with a mixed solution of chloride of aluminium and common salt and packed iu air-tight barrels, or it may be kept in ordinary barrels simply packed with dry salt.

Robin employed some of the volatile hydrocarbons, as ether, in a capsule or sponge placed within a case containing the substance to be treated, the vapor preventing corruption. Fish may be preserved for some time iu sugar, either alone or with saltpeter or common salt; treated in this way, they retain their natural flavor to a greater degree than in the ordinary salting process; if afterward dried, they may be kept for an indefinite period.

Smoking. This is usually employed in conjunction with salt. The meat, having been previously immersed in or thoroughly rubbed with salt, to which a proportion of sugar and saltpeter is usually added, is suspended over a smoldering wood-fire which burns slowly but emits a large quantity of smoke. Green hickory is preferable for smoking, wood of the pine family imparting a disagreeable flavor to the meat. In some cases the twigs or branches of aromatic plants are added to the fuel; juniper is used for smoking the celebrated Westphalia hams. Corn-cobs are frequently used.

Exclusion of air. In 1808, M. Appert invented a process for preserving provisions by parboiling, and inclosing them in earthenware-vessels from which the air was excluded. This as subsequently improved by Donkin and Gamble forms the basis upon which the more receut processes of preserving foods by canning are founded.

In that patented by Donkin the meat is first parboiled or somewhat more, freed from the bones, and then placed, either alone or with vegetables, in tiu canisters which are filled with prepared gravy or juices; a tin cover with a small aperture is soldered over the open end of the can, which is then placed in boiling water or in a salt solution heated slightly above the boiling-point of water, thus expelling the air from the interior. When this is effected the aperture is closed with solder while the contents are yet hot. On cooling, the ends of the can assume an inwardly coucave form, on account of the contraction of the contents. The success of the process is tested by exposing the cans for some time to a heat above 100° Fah., when, if incipient putrefaction had set in previous to the commencement of the process or it has been improperly conducted, the generated gases will cause the ends of the cau to bulge outwardly.

Bevan's process, patented 1842, consists in exhausting the air from the cans previous to heating them, and in providing a supply of gelatine which is caused to flow in and fill the vacuum as the air is withdrawn, thus enabling the food to be cooked iu a vacuum at a much lower temperature.

Potting. By this method air is excluded from animal substances previously cooked, by placing them in jars and covering them with a layer of lard, butter, or oil.

Pickling. This term is applied indifferently to the preservation of meats or vegetables in brine or vinegar. Brine is generally used for keeping meat, and vinegar for vegetables. This process forms an important part of household economy, and on a large scale constitutes a prominent source of national wealth.

Cabbage, sliced and packed in salt, undergoes a slight fermentation forming sauerkraut, an article of diet largely used in Northern Europe. Potatoes, turnips, and other roots, as well as apples and cabbages, are prevented from decaying by storage in moderately cool, dry situations.

Fruits are preserved by desiccation or by being treated with sugar, and either dried or retained in the sirup. The former are known as *dry* and the latter as *liquid confections;* they are usually boiled in the sirup.

Marmalades, *jams*, and *pastes* are prepared by beatiug up the pulp of fruits with liquefied sugar or honey. *Conserves* are beaten up with dry sugar.

Some fruits, as grapes, may be kept a long time by merely being loosely packed in sawdust; others are treated with alcoholic spirits and sugar.

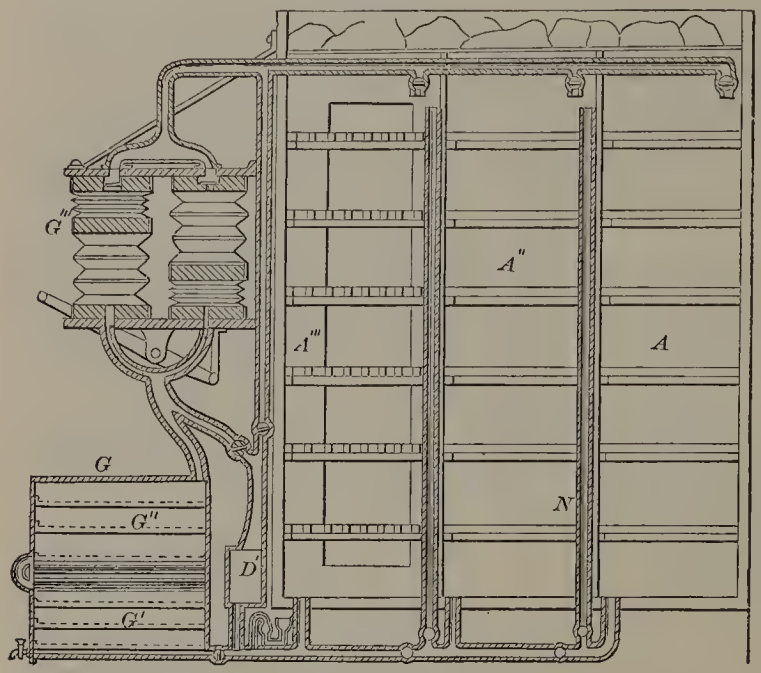
Milk may be preserved by reducing it by boiling to half its natural bulk, and beating it up with the yolk of eggs in the proportion of $8\frac{1}{2}$ to $10\frac{1}{2}$ quarts of milk; the whole is then heated for half an hour and frequently skimmed, strained, and again heated for two hours in a water-bath. See MILK, CONDENSED, page 1438.

A preferable method, generally pursued in the preparation of condensed milk, is to evaporate it at a gentle heat and add sugar. Milk thus prepared contains about 25 per cent of water, 29 per cent of cane, and 16 per cent of milk-sugar. Evaporation may be continued until the milk is entirely solidified.

Cream may be preserved by boiling down five measures to four, cooling and skimming, and then placing in closely stopped bottles, which are kept in a water-bath at a boiling heat for half an hour.

Pre-serv'a-to-ry. An apparatus for preserving substances to be used as foods, etc. In the example (Fig. 3933), the articles are placed within the chambers *A A''*, etc., connected with a combustion-chamber *D'*, by which the air is desiccated and its oxygen partially removed; it is afterward passed through

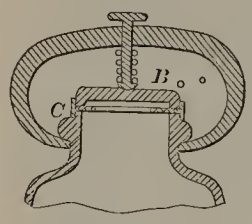
Fig. 3933.



Preservatory.

the deoxygenating-chamber *G G'*, containing a compound which has an affinity for that gas, and which combines with that remaining after desiccation. The air, both before and after deoxygenation, is caused to circulate through the various parts of the apparatus by means of the bellows *G'''*.

Fig. 3934.



Preserve-Jar.

Pre-serve'-jar. A jar the mouth of which may be hermetically closed, both to insure the better preservation of the fruit and to prevent evaporation. Various devices have been contrived for effecting this object. In the example, a flanged packing-ring *C* accurately fits the mouth of the bottle; over this and within the flange is placed the cap *B*, which is forced tightly down upon an india-rubber gasket by the pressure of a screw so as to exclude the air. See FRUIT-JAR.

Pre-serv'ing Wood. See WOOD, PRESERVATION OF.

Press. See under the following heads: —

Anti-friction press.
Arming-press.
Autographic press.
Baling-press.
Beater-press.
Bibble-press.
Blocking-press.
Bonnet-press.
Bramah-press.
Brick-press
Bundling press.
Button-press.
Cancelling-press.
Cane-press.
Cardboard-press.
Casting-press.
Centripetal-press.
Cheese-press.
Cider-press.
Cigar-press.
Cloth-press.
Coining-press.
Color-printing press.
Concrete-press.
Copperplate-press.
Copying-press.
Cork-press
Corundum-press.
Cotton-press
Crimp-press.
Cutting-press.
Cylinder-press
Cylindrical printing-press.
Domestic press.
Double-cylinder press.
Drop-press.
Drum-press.
Dry-press.
Embossing-press.
Filtering-press.
Finishing-press.
Flat-press
Flour-packer
Fly-press.
Foot-press.
Fruit-press
Gauffering-press
Glass-blower's press
Gluing-press.
Gulleting-press.
Gunpowder-press.
Hand-stamp.
Hat-press.
Hay-press.
Hop-press.
Hot-press.
Hydraulic press.
Hydrostatic press.
Lard-press.
Level-press.
Lever-press.
Lithographic press.
Oil-press.
Packing-press.
Pad-crimp press.
Paper hot-press.
Pawl-press.
Peat-machine.
Peat-press
Perfecting-press.
Photo-relief press.
Portable-press.
Printing-press.
Proving-press.
Railway press.
Re-pressing press.
Revolving-press.
Rolling-press.
Rolling-cam press.
Screw-press.
Seal-press.
Sewing-press.
Sheet-metal press.
Stabbing-press.
Stamping-press.
Standing-press.
Stanhope-press.
Stearine-press.
Sterhydraulic apparatus.
Striking-up press.
Sugar-press.
Swing press.
Tincture-press.
Tobacco-press.
Toggle-press.
Transferring-machine.
Upsetting-press.
Vencer-press.
Voluntary-press.
Water-press.
Web-press.
Wedge-press.
Wet-press.
Wheel-press.
Wine-press.
Wire-press.
Wool-press.

Press-cake. (*Gunpowder.*) Incorporated or mill cake ready to undergo granulation.

Presse-ar-tère'. (*Surgical.*) An instrument with a handle and a plate with two perforations; the latter to hold a ligature, which is passed round an artery, and draws it up against the plate, the cords of the ligature being secured to the stem.

Pressed Brick. Bricks placed one at a time, when nearly dry, into a metallic mold, in which they are forcibly compressed by the action of a lever or screw, which forces up the piston forming the bottom of the mold. This gives a smooth face to the brick, and leaves the arrises very sharp.

Pressed Glass. Glass brought to shape in a mold by a plunger.

A modification consists in blowing it within a mold so as to make it assume the form of the latter.

Pressed Loop. (*Harness.*) A leather loop, the top of which is pressed up with an ornamental stamp.

Press'er. 1. The bar in a knitting-machine which drives the barb of the needle into the groove of the shank in order to let off the loop.

2. A form of ironing-machine.

3. The foot-piece in a sewing-machine which rests upon the cloth to hold it steady while the needle penetrates and withdraws, and then rises to allow the cloth to be fed. A *presser-foot.*

4. (*Spinning.*) *a.* The pressure-roller of a drawing-frame.

b. The spring-finger of a bobbin-frame.

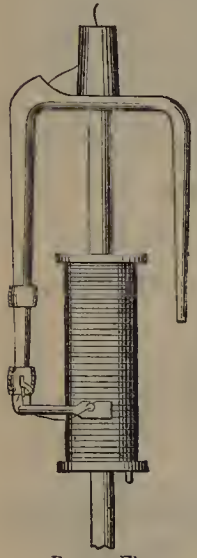
Press'er-bar. (*Knitting-machine.*) A bar which presses upon the barb of the hook, so as to close it against the shank of the needle. By this means the loop in the hook is held therein while the loop

previously made is brought over the closed needle and the loop within it.

Press'er-fly'er. (*Spinning.*) *a.* That form of machine in which the arm of the flyer is pressed against the bobbin by a spring.

b. One which has a spring arm pressing upon the bobbin upon which it delivers the yarn. See FLYER.

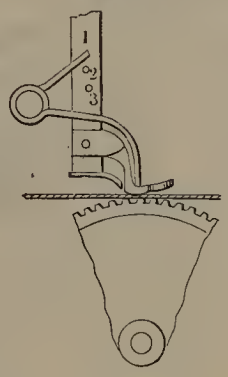
Fig. 3935.



Presser-Flyer.

Press'er-foot. (*Sewing-machine.*) A foot-plate which presses upon the goods and holds them against the rough face of the feed.

Fig. 3936.



Presser-Foot.

Press'er-frame. (*Spinning.*) One furnished with *presser-flyers.*

Presse-u-rèthre'. (*Surgical.*) A clamp for the penis to draw the parietes of the urethra together and prevent the discharge of urine. *Jugum-penis.*

Press'ing-bag. The horsehair cloth bag in which flaxseed or stearic acid is pressed.

Press'ing-board. 1. An ironing-board upon which seams are pressed.

2. (*Bookbinding.*) A board placed between a layer of books when piled in the *standing-press.*

Press'ing-plate. A follower-board in an oil-press; board and bags of the material alternate.

Press'ing-roll'er. (*Paper.*) *a.* A wire-gauze roller which takes up the moisture from the felted pulp in paper-making.

b. The roller which presses the sheet of damp paper to remove moisture.

Press-keys. Brass keys to hold tightly the strings in a sewing-press.

Press-pin. The iron lever of a screw-press.

Press-print'ing. (*Porcelain.*) One of the modes of printing porcelain. The other is BAT-PRINTING (which see).

In press-printing the engraving is coarse, the lines being very heavy, so as to hold a sufficiency of ink. The impression is taken on *porcelain-tissue* paper; the marginal paper of the pattern is then cut away and the impression dabbed against the *biscuit.* It is then rubbed with soapy flannel and finally with a roll of flannel. By damping and rubbing, the paper is then removed, leaving the oily ink adhering to the biscuit. The oil being driven off in a *hardening-kiln,* the ware is ready for glazing. *Press-printing* is applied to biscuit; *bat-printing,* to the glazed ware.

Press-stone. (*Printing.*) The bed of the press.

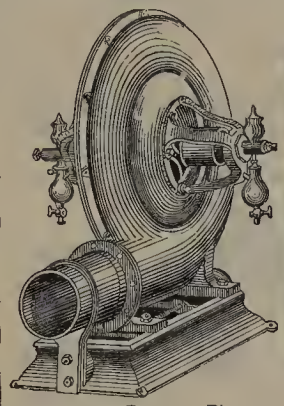
Press'ure-blow'er. One in which the air is driven by a positive pressure by pistons rotary or otherwise, in contradistinction to one in which the air is projected by fans working to produce a centrifugal action of the air by the speed of movement of radial vanes. See BLOWER. See also Fig. 2589.

Press'ure-en'gine. A water-pressure engine. See HYDRAULIC ENGINE.

Press'ure-fil'ter. A filtering-chamber placed in a pipe under a head of water.

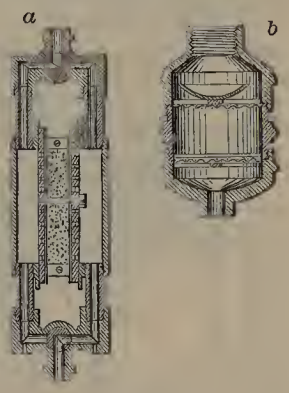
In Fig. 3938, *a* has two casings with perforated plates on the inside and a body of sand confined between the plates, together with a system of pipes and three-way cocks, whereby the water may be conducted first in one direction and then in another through the sand.

Fig 3937.



Sturtevant Pressure-Blower.

Fig. 3938.



Pressure-Filter.

In Fig. 3938, *b,* the chambers are separated from each other by two partitions, consisting of wire-cloth and filtering material, supported by cross-bars; the upper partition supports a cup which is intended to break the force of the current of water.

Press'ure-forg'ing. A method of forging and swaging metals by hydraulic pressure. At the State Railway Works, Vienna, two presses capable of giving respectively 1,500 and 600 tons pressure are employed. Heated ingots of Bessemer steel, weighing 2,030 pounds, are placed under a hammer-like head attached to the piston and gradually squeezed into the form of bars, being shifted and turned as required when the piston is raised. The bar is then cut into lengths by a chisel attached to a press. The masses thus cut off are swaged to the desired form in molds by suitable dies attached to the piston. There is no jar or vibration in this machine, as in the steam hammer, and it is very expeditious in its operation, rendering it well adapted for complicated forgings, such as locomotive cross-heads, boiler-heads, steam-domes, etc., and also for spokes. See also FORGING-PRESS.

Press'ure-frame. (*Photography.*) Often called *printing-frame* and sometimes *press.* A strong shallow open frame of wood surrounding a square of thick plate-glass which rests upon a rabbet. When a positive "print" on sensitive paper is to be made from a photographic negative, the latter is laid with the collodion side upward upon the plate-glass front above described. A sheet of sensitized chloride of silver paper is then pressed into close contact with the negative, by a number of strong springs attached to hinged pieces which lock across the back of the frame, acting upon a movable wooden back separated from the sheet by suitable soft packing. When such a frame is turned up with its plate-glass side toward the sun, the light passing through the negative darkens the paper behind, so as to produce the positive picture or "print." The wooden back upon which the springs act is divided into two parts, which are hinged together. By means of this expedient, it is possible to examine from time to time the progress made in printing,

one half the back being raised while the other holds the paper firmly in place upon the negative, and to stop that operation when the shadows are sufficiently dark.

Press'ure-gage. 1. (*Steam-engine.*) An apparatus or attachment for indicating the pressure of steam in a boiler.

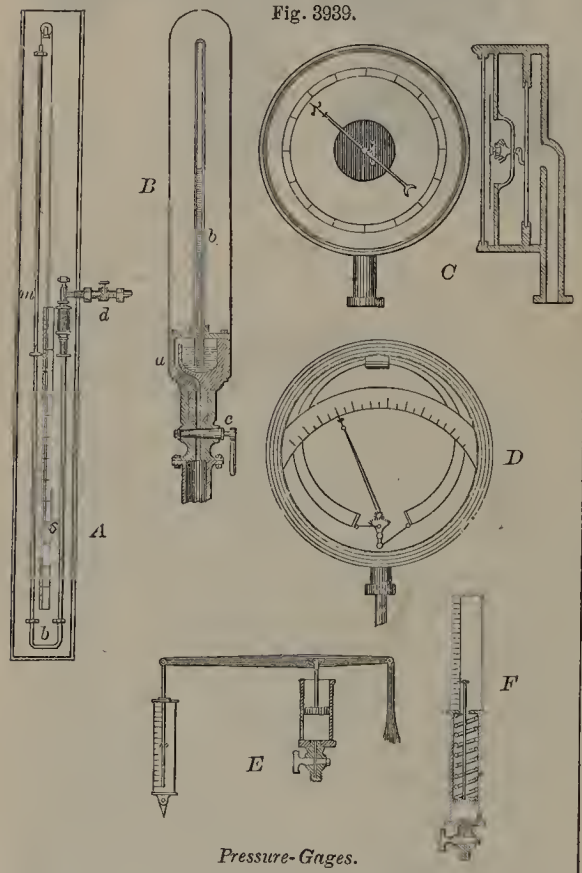
It assumes various forms.

a. A *safety-valve* is in one sense a *steam*-gage, as it indicates the attainment of a certain pressure. See SAFETY-VALVE.

b. A plug of fusible metal, compounded so as to melt at a certain temperature and inserted in the side of the boiler, is a *pressure-gage*, as it melts and allows the steam to escape under the circumstances designated. See ALLOY; FUSIBLE METAL; HIGH-PRESSURE ALARM.

c. The mercurial steam-pressure gage (*A*) is a

Fig. 3939.



Pressure-Gages.

bent tube leading into the steam-generator at the end *d* and open to the air at the other end. A body of quicksilver occupies the bend *b*, and is elevated in the outer leg *m* of the tube by the pressure of steam on the mercury in the inner leg. A graduated plate shows the range within the pressures for which the generator is calculated. When the column in the outer leg stands thirty inches higher than that in the inner leg, it shows a pressure of two atmospheres, and so on. For great pressures it requires a long leg or that the column be loaded.

If the siphon-tube be of glass, the indicated pressure may be easily read; but to avoid fracture the tube is frequently made of iron, and the level of the mercury is indicated by a float.

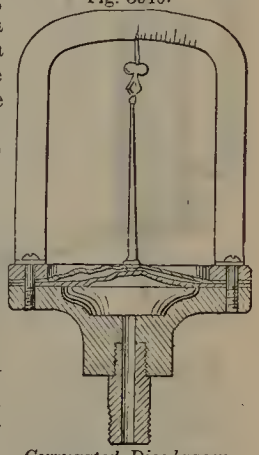
As the mercury in the long leg *m* rises, it will raise the float, the counterpoise of which *s* will descend and indicate upon the scale the excess of pressure of steam over the pressure of the atmosphere. Each two inches of the vertical column of mercury is equal to about one pound effective pressure in the boiler.

In high-pressure boilers, the great hight of the column of mercury would prove inconvenient, and therefore another form (*B*) is adopted.

a is a cistern of mercury, and *b* a glass tube whose lower end is open and plunged in the mercury. The tube contains air at ordinary pressure. When the stopcock *c* is opened, the steam from the boiler enters by the duct *d* and presses upon the surface of the mercury in the cistern, raising it in the tube and compressing the air. When the air is condensed to half its volume, its pressure is doubled; when it occupies only one third the space, its pressure is threefold, and so on.

d. In the Magdeburg pressure-gage (*C*) the fluid is admitted by a tube to the rear of an elastic diaphragm, whose motions actuate a toothed sector engaging a pinion on the spindle of the pointer, which indicates the pressure on a graduated arc. The action is analogous to that of the aneroid barometer. The diaphragm is generally corrugated in steam-pressure gages. See STEAM-GAGE.

Fig. 3940.



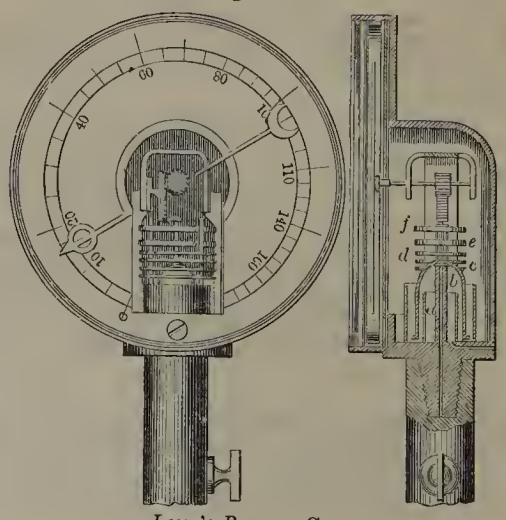
Corrugated Diaphragm Pressure-Gage.

In Fig. 3940, the corrugated disk is made more sensitive or capable of greater action on one side of its axial line than on the opposite side, by giving a varied or unequal construction to the corrugations. The capacity for expansion being greater on one side than the other, the index-finger, which is axial in the normal state, is tipped by the rising of the diaphragm, and its inclination is registered on the graduated bar.

e. Bourdon's aneroid-gage (*D*) is a bent tube which is closed at its ends and held by its midlength, at which the fluid is admitted. The pressure of steam or other fluid has a tendency to straighten the tube, whose ends are connected to a sector-rack, which operates an indicator in the manner just described.

f. In the *piston-gage* the steam acts upon the surface of a disk within a cylinder. The piston-rod is connected with a weighted lever (*E*) or a spring (*F*), which acts against the steam-pressure, the amount

Fig. 3941.



Lowe's Pressure-Gage.

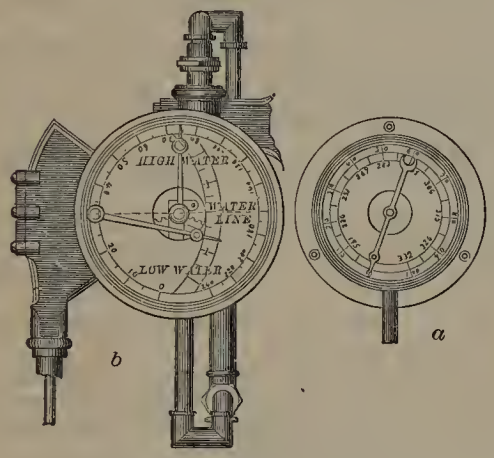
of which is indicated in the usual way. This is the principle of Watt's indicator.

Lowe's steam-gage consists of a tube *a* having a small hole through which steam is admitted to the interior of the receiver *b*, raising it into contact with the annular weight *c*, which is thus caused to rise, becoming successively loaded with the upper weights *d e f*, etc., as the steam-pressure increases. A rod passing centrally through the weights carries a rack which gears with a pinion on the axis of the indicator of the dial.

A series of cylinders, one within the other, may replace the annular weights, rendering the whole more compact.

One form of Ashcroft's well-known gage has two

Fig. 3942.

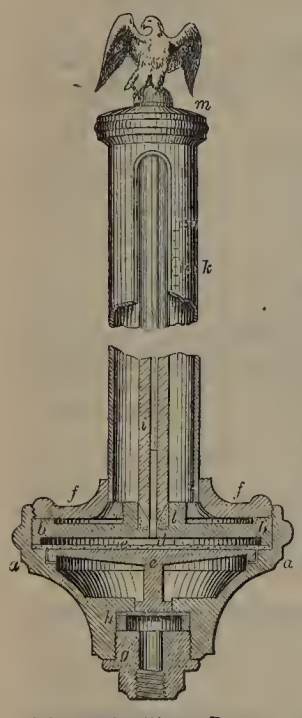


a, *Ashcroft's Steam-Gage.*
b, *Graeber's Steam and Water Alarm-Gage.*

graduated circles, one representing the pressure and the other the temperature.

Shaw's pressure-gage (Fig. 3943) consists of a brass cup *a* containing an iron disk *b* recessed on its lower side to form a mercury chamber. *c* is a double-headed piston having its upper and larger head covered by a gum diaphragm *d*, and receiving the pressure of the mercury, which passes into the chamber *e* when pressure is applied to the small head of the piston *c*. *f* is a screw-cap, making a tight joint and preventing escape of mercury into the lower part of the cup *a*. *g* is a nut having an orifice for the steam connection, and *h* a perforated gasket, making an air and steam tight joint. The lower and smaller head of the piston *c* receives the steam pressure, and forces the mercury into the chamber *a* through a small perforation in the disk *b*, whence it rises into the glass tube *i* to a hight indicated by the graduated register *k*. A gum ring or cushion *l* receives the conical end of the tube *i*, which is firmly pressed upon it by screwing down the cap *m*. See also STEAM-GAGE.

Fig. 3943.

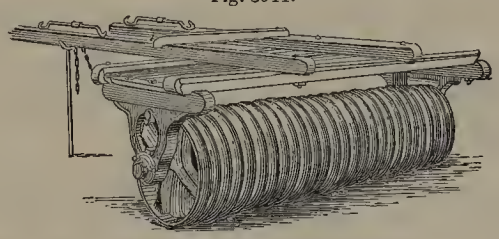


Differential Piston Pressure-Gage.

2. (*Nautical.*) A deep-sea pressure-gage is one which is constructed for measuring depths by the amount of compression to which the contained fluid is subject when submerged to great sea depths.

Press-wheel Roll'er. One constructed of a series of wheels which combine to form a rolling ridge and hollow face, and avoid clogging, or the necessity for a scraper to clean the roller. They are

Fig. 3944.



Cylindrical Press-Wheel Roller.

arranged upon self-lubricating axles, with hard-metal removable bushes attached to the iron outside brackets. The weight of a roller, seven feet by two feet, is one ton.

Press-work. 1. (*Joinery.*) Cabinet work of a number of successive veneers crossing grain, and united by glue, heat, and pressure.

2. (*Printing.*) The printing of a form.

Pre-vent'er. (*Nautical.*) An additional rope, spar, chain, or bolt, as a support, stay, or substitute. A supplementary or auxiliary rope to support a spar, stay, etc., in a gale or in action.

A *preventer-bolt* is driven at the lower end of the *preventer*-plates to assist the strain of the chain-bolts.

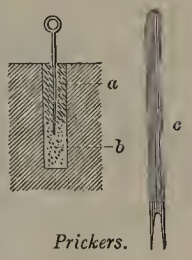
Preventer-plates are placed below the links of the chains.

Preyne; Prin. A technical term in some trades for a pin or needle.

Prick. (*Nautical.*) To trace a ship's course on a chart.

Prick'er. 1. (*Blasting.*) A priming-needle. A pointed copper wire with a ring head. It is forced into the charge *b*, and the tamping *a* is pounded around it. The pricker is then withdrawn, leaving an opening into which a little fine powder is poured to make a connection from the fuse to the charge.

Fig. 3945.



Prickers.

2. (*Gunnery.*) A sharp wire introduced at the vent to puncture the bag which holds the charge, in order that the priming may touch the powder.

3. (*Nautical.*) A small instrument having an enlarged head and a curved tapering point. It is similar to the fid and marline spike, but is used for smaller work.

4. A long slender iron rod used for probing or sounding the depth of a bog or quicksand.

5. (*Saddlery.*) *a*. A toothed roller for marking or stabbing holes for sewing leather, etc.

b. A tool (*c*) used to mark stitch-holes so as to render them uniform in distance.

Prick'ing-up. (*Plastering.*) The first coat of plaster on lath; the surface is scratched to form a key for the next coat. See PLASTERING.

Prick'ing-wheel. (*Saddlery.*) A traveling tool

which marks the number of stitches to the inch. A *stitch-wheel.*

Prick-post. (*Building.*) A post framed intermediately between two principal ones.

Prick-punch. (*Forging.*) A pointed instrument used by smiths to mark their centers.

Prick-wheel. (*Saddlery.*) A tool used to prick off the work for the harness-stitcher, the points being made to produce a certain number of marks.

Priest's Cap. (*Fortification.*) An outwork with three salient and two entering angles.

Prill. (*Mining.*) The better portions of ore from which inferior pieces (*dradge*) have been spalled by the cobbing-hammer.

Prill'ion. (*Mining.*) Tin extracted from the slag.

Pri'ma. (*Printing.*) The first form of a sheet.

Prime. 1. (*Gearing.*) A number which is only divisible by itself or unity. Numbers *prime* to each other have no common factor except 1.

In wheel work, it is usual in any wheel and pinion that act on each other to use numbers of teeth which are *prime* to each other, so that each tooth of the pinion may encounter every tooth of the wheel in turn.

2. (*Steam.*) To carry over water with the steam.

3. To put powder in the pan of a fire-arm, or lay a train of powder to a charge.

4. (*Printing.*) A mark over a reference letter (*a'*, *b''*, etc.) to distinguish it from letters (*a*, *b*, etc.) not so marked.

Prime-con-duct'or. (*Electricity.*) The metallic conductor opposed to the glass plate or cylinder of an electrical machine. It is supported by a glass stem, and may be connected by chain with the object to be excited or with a Leyden jar or battery when the influence is accumulated.

Pri'mer. 1. (*Ordnance.*) *a.* A small, supplementary tube used with some descriptions of heavy, breech-loading ordnance. It is placed in the horizontal part of the vent before the vent-piece is placed in the gun, and communicates the flame from the ordinary tube to the cartridge.

b. A wafer, cap, or tube containing a compound which may be exploded by percussion or by friction; used for igniting the charge of powder in a cannon. Those generally used in the navy are made from quills which are nearly filled with fine-grained gunpowder, the upper part of the quill being split and turned over for containing a capsule of fulminate which is exploded by a sudden blow of the lock-hammer. Friction-primers (which see) are exclusively employed in the land service.

2. (*Blasting.*) *Tape primers* are used for firing charges at a distance. They are formed of long flexible strips of paper or fabric containing fulminate or other quick-burning compound, and are covered with a water-proof composition.

A detonating primer used in blasting with gun-cotton consists of a frusto-conical tube having its lower end filled with a detonating composition, above which is a layer of gun-cotton; the upper part of the tube is empty, and is covered with a paper cap; an ordinary fuse is inserted into this cavity and fired in the usual manner.

Prim'er. (*Printing.*) Two sizes of type are so called: *Great Primer*, the largest used in book-printing, measuring 51 ems to the foot; and *Long Primer*, a size intermediate between *Small Pica* and *Bourgeois*, measuring 89 ems to the foot.

Bourgeois, 102 ems to a foot.
Long Primer, 89 ems to a foot.
Small Pica, 83 ems to a foot.
Pica, 71 ems to a foot.
English, 64 ems to a foot.
Great Primer, 51 ems to a foot.

Prim'ing. 1. (*Painting.*) The first layer of paint, size, or other material laid upon a surface which is to be painted or glazed; as on a canvas, picture-frame, stuff, wall, vehicle, building, or other object.

The priming of the gilder on wood is composed of *white-stuff*, size, and whiting. See GILDING.

2. (*Fire-arms and Ordnance.*) The combustible which communicates fire to the charge.

3. (*Blasting.*) A train leading to a bursting-charge.

4. (*Steam.*) The carrying over of water with the steam into the cylinder.

Prim'ing-horn. (*Blasting.*) The powder-horn of the miner or quarryman.

Prim'ing-pow'der. 1. Detonating powder.

2. The train of powder connecting a fuse with a charge.

Prim'ing-tube. (*Ordnance.*) A tube to contain an inflammable composition, which occupies the vent of a gun whose charge is fired when the composition is ignited.

There are several kinds of priming-tubes, fired by *port-fire*, *lock*, or friction.

The tube is made of *quill*, *paper*, or *metal*, and is charged with mealed powder damped with methylated spirit, or by a detonating composition, such as chlorate of potash and antimony.

The tube is slightly smaller than the gun-vent, in the relative proportions of $\frac{2}{10}$ and $\frac{3}{5}$ of an inch, and a hollow is made down the middle of the composition, so that the fire may involve the whole length instantaneously.

The simplest form is that in which the tube is merely a holder for the priming, which is touched off by a port-fire. This is the *quill*, Dutch, or *common metal tube.*

Another variety has a cross-head or snipe to contain a detonating composition which is exploded by a hammer. This is the *cross-headed* or *detonating tube.*

A third variety is operated by friction, a roughened bar occupying the hollow in the composition, and exploding by friction the detonating composition in the head of the tube. The rough bar is jerked out by a lanyard. See FRICTION-PRIMER.

Prim'ing-valve. A spring valve fitted to the end of a cylinder, to permit the escape of water without danger to the machinery from the shock of the piston against the incompressible fluid. This water collects partly from the condensation of steam within the cylinder, but is chiefly carried over from the boiler, either as *priming* or in a state of mechanical suspension with the steam.

Prim'ing-wire. (*Ordnance.*) A pointed wire to prick a cartridge when it is *home* and clear the way for the priming or loose powder. A flat-headed wire to clear the vent of any ignited particles. Fig. 3945.

Prince Ru'pert's Met'al. An alloy for cheap jewelry, etc.

A brass composed of copper, 75; zinc, 25. *Pinchbeck.*

Prince's Met'al. A jeweler's alloy of copper, 72; zinc, 28.

Prin-cet'tas. A worsted fabric, sometimes with a cotton warp.

Prin'ci-pal. 1. (*Carpentry.*) An important timber in a frame, as a *principal beam.*

A *principal rafter*, one of the heavy rafters which support the *purlins* and common rafters.

A *principal brace*, one immediately under the principal rafter.

A *principal post*, the corner post of a frame.

2. (*Music.*) A stop of an organ an octave higher than *open diapason* and in unison with *flute.* It is the first or medium stop which is tuned, all the other stops being tuned from it. See STOP.

Prin'ci-pal Raft'er. (*Carpentry.*) A rafter in the main truss upon which the purlins rest.

Print. 1. (*Fabric.*) A cotton cloth printed. *Calico.*

2. A mold sunk in metal from which an impression is taken by swaging. A *boss.* A *swage.*

3. (*Foundry.*) A projection on a pattern which leaves a space in the sand for the purpose of supporting a core in its right position and place. The space is entirely filled by the core, and its length is always that of the hole in the casting, and the print, or prints when two are used, which is commonly the case.

Print'ed Car'pet. A carpet dyed or printed in colors. By one process, the carpet, after weaving in undyed colors, is printed in the same manner as calico.

Another mode is to dye the yarns in bands or sections, which are adjusted and proportioned to their future position in the fabric.

Whytock's Brussels carpet (English) was designed to save woolen material by substituting a party-colored woolen yarn for the five yarns of various colors which usually accompany the linen warp in Brussels carpet (which see). The yarn is dyed of the requisite color at different places. The succession of colors is determined by a design-paper containing the pattern, ruled with squares, the lines being numbered along the top and down the length, and containing the entire figure of the pattern. The breadth of the band of color on the yarns and their due succession are determined thereby. The weaving is conducted in the manner adopted with velvet, without the complicated adjuncts incident to figure weaving.

Print'ed Ware. (*Pottery.*) Porcelain, queensware, etc., ornamented with printed figures or patterns; this is usually done previous to glazing the ware. An impression is taken on yellow unsized paper, previously dipped in soapy water, from an engraved copper plate to which the coloring matter has been applied; the pattern is then cut out from the sheet, laid printed side down on the plate or other article, and rubbed with a piece of flannel until the color is transferred; the article is then placed in water and the adhering paper removed, after which it is heated to expel the water and afterward glazed. In some cases the impression from the plate is taken in oil only, on a flexible sheet of glue called a *paper* or *bat*, and transferred to the article, which is then dusted over with the pulverized color in a dry state. The glue is cleaned by sponging and is ready for use again.

Print'er's Flow'er. (*Printing.*) A *tail-piece.* An ornament at the end of a printed book.

Print'er's Gage. *a.* A four-sided stick for measuring the work of a compositor. Each side of the stick is a gage for a particular type.

b. A rule cut to the length of a page, by which to *break* matter in *making up* pages.

c. A trial piece of *furniture* of proper size to regulate the distance between pages in imposing a form. The *furniture* is then cast or made up to such a size as, in conjunction with the chase-bars, to equal the *gage.*

Other gages are used in cutting and mitering rules, *setting* composing-sticks, etc.

Print'er's Roll'er. A soft elastic cylinder which imparts ink to a form.

The invention of the roller, simple as it seems, was so great a step in advance as almost to revolutionize the art of printing. Without the elastic inking-roller modern fast printing-presses would be impossible.

Previous to the invention of the roller, forms were inked by hand by *dabbing* with *balls* of soft leather on which ink was spread by rubbing together, one being held in each hand by the workman. The balls were stuffed with tow or cotton and attached to handles.

The first composition for rollers was glue and molasses. This is still in use. Other compounds are glue and glycerine, glue and honey, etc.

The glue is melted by steam heat to avoid burning, the molasses or other ingredients added; and the whole mass cooked until it arrives at a proper consistency, which is determined by cooling a small quantity. Donkin and Bacon's English Patent, 1813.

The roller is cast in a hollow cylindrical mold, a wooden core with metallic bearings being first placed centrally in the mold. See INKING-ROLL.

Print'er's Var'nish. Linseed or nut oil boiled and kindled till it acquires a certain consistence; to this black resin is added, $\frac{3}{4}$ to 1 pound to the quart of oil, stirred; $1\frac{1}{4}$ pound of dry brown soap added, stirred, boiled. May be diluted with oil of turpentine for use. See LITHOGRAPHIC VARNISH, page 1333.

Print-hold'er. (*Photography.*) A small frame for suspension from a nail or supported at the back in the manner of an easel, adapted to hold and exhibit a photograph. See also PRESSURE-FRAME.

Print'ing. 1. *a.* The art of taking an impression from an inked form, plate, block, or stone.

Speaking generally, the art is at least forty centuries old. Ancient Assyrian and Egyptian seals exist, whose surfaces were blacked and then pressed upon bark, a leaf, or skin, delivering an impression either with white marks on a black ground or black on a white ground, according to the character of the engraving, whether the lines of the design were cut in or left salient.

The rude king who smeared his hand with red ocher or the soot from a burning lamp and then made the impression of the palm and digits beneath a grant of land, was a printer in his way in thus *putting his hand* to the document.

As a substitute for the *sign-manual*, kings of old stamped their names or pronomens upon their grants and orders. See SEAL.

In the capitals of the great kingdom of Mesopotamia, which, in its day, was the most densely populated part of the earth, the impressions of the stamps and seals of the recorders and scribes are discovered in thousands. Tablets of clay were impressed by engraved cylinders and then baked, and have remained to this day. See SEAL.

"It is turned as clay to the seal." — *Job.*

This is not printing as we understand the word, but is closely allied; the ceramic works of the Assyrians, Egyptians, Phœnicians, Cyprians, and Etruscans have been, by their composition, proof against decay, and show the kindred arts of plastic molding, engraving, painting, and transferring, the latter being a mode of delivering upon an object an impression from a surface previously marked or inked with the design required to be repeated.

Some of the ancient stamps in the British Museum are of bronze, and have raised reversed letters, evi-

dently intended to print on bark, leaves, papyrus, linen, or parchment. These stamps have handles. They were in use among the Romans before the Christian era.

The first notice that we find of printing pages is in the Chinese annals. Du Halde cites the following, from the pen of the celebrated Emperor Van Vong, who flourished 1120 years before Christ: —

"As the stone Me [a word signifying ink in the Chinese language], which is used to blacken the engraved characters, can never become white; so a heart blackened by vices will always retain its blackness."

From this it appears that printing from blocks was a very ancient art. Other Catholic missionaries besides Du Halde concur in supposing it to have been invented from 930 to 950 B. C.

The Chinese process is described by Sir J. F. Davis, and it is probable that it has remained substantially the same for a score of centuries.

The block commonly used by the Chinese is pear-tree wood. It is finely planed and squared to the dimensions of two pages. The surface is then rubbed over with a paste or size, occasionally made from boiled rice, which renders it quite smooth. The future pages, which have been transcribed on thin transparent paper, are delivered to the block-cutter, who sticks them face down to the block by the sizing just mentioned. The thinness of the paper permits the writing to show through perfectly. The paper being rubbed off, a clear impression of the ink remains on the wood. The workman then cuts away all that part of the block not covered by ink, leaving the characters in relief. The pages are then ready to print.

The first four books of Kung-fu-tze were printed, according to Klaproth, upon page blocks in the province of Szut-schuen, between 890 and 925 A. D., and the description of the technical manipulation of the Chinese press might have been read in Western countries as early as 1310 in Raschid-eddin's Persian History of Cathay.

No press is used in printing, but the workman holds in his right hand a stick with a brush at each end. With one brush he applies ink to the page, then lays on a sheet of thin paper, like tissue-paper, and runs the dry brush over it, so as to make the impression. The paper is printed on one side only, and the blank side is turned inward, leaving the fold on the outside of the pages. A Chinese book thus has the appearance of an uncut volume.

This plan was used in Europe in the thirteenth century for printing playing-cards and the works known as *block-books*, each page being an engraved block, like those of the Chinese.

In the year 1041, a Chinese blacksmith named Pi-Ching invented a method of printing from plates formed from movable types of burnt clay, called *ho-pan*, that name being still used to designate the plates in use at the Imperial printing-office. The types of Pi-Ching were of the thickness of a Chinese coin, and each had a word on its face. A plate of iron was covered with fusible mastic, and the letters were laid upon it in lines running from the top downward. The plate was then heated and the types were forced into the mastic, being *planed down* to a level surface by pressure. When the edition was printed, the mastic was again heated and the types removed.

The vast number of characters used in the Chinese language, which is not phonetic and has a symbol for each word, renders it doubtful whether there is any advantage in using movable types over engraved blocks. The printing-office established by American missionaries in China has 6,000 different characters in its font of type. The types now in use in China are of similar form to our own.

The works of Gotama, under the title of "Verbal Instructions," are published by the Chinese government in four languages, — Thibetan, Mongol, Mantchou, and Chinese, — from the Imperial press at Pekin, in 800 large volumes. The name of this founder of Buddhism was Arddha Chiddi. He was born about 1700 B. C, at Capila, near Nepaul. This religion now embraces Ceylon, Tartary, Thibet, China, Japan, and Burmah. He changed his name to *Gotama*, "one who kills the senses," in allusion to the sublimation of the soul by physical mortifications.

It appears that the Venetians introduced block-printing into Europe, and wood-engraving and printing had long been in use in the time of Charles V., when playing-cards were thus made. The printing from blocks is said to have been practiced at Ravenna in 1289, and among the Germans in 1300. In 1441 it had attained the dignity of special legislation; the Venetian card-makers, taking their impressions by means of a burnisher, obtained protection against the introduction of "stamped cards."

The most important of the *block-books* was the "Biblia Pauperum," or poor man's Bible, which was a book of from 40 to 50 pages, with scenes and incidents from the Bible. It was a great favorite for four or five centuries, existing at first in the manuscript form; it was printed from blocks in 1440, and remained as a block-book long after the invention of separate-type printing by Guttenberg. The book had several authors, but its first compilation is ascribed to Bonaventura, the chief of the Franciscans, in 1260.

John Guttenberg (called Geinsfleisch, from the name of his house) was born in 1400 at Mentz. In company with Faust and others he printed several works with *wooden types* and *wooden blocks*. These were the "Alexandri Galli Doctrinale" and "Petri Hispani Tractatus," in 1442; and subsequently the "Tabula Alphabetica," "Catholicon," "Donati Grammatica," and the "Confessionalia," between the years 1444 and 1450. In the years 1450–55, the Bible of 637 leaves was printed by Guttenberg and Faust with *cut metal types*. Guttenberg died in 1468, in high honor for his genius and perseverance. Faust, after dissolving partnership (1455) with Guttenberg, became allied with Schoeffer; and they published in 1457 the "Codex Psalmorum" with metallic types, — the most ancient book with a date and inscription.

Guttenberg took other partners, and published the "Catholicon Jo. de Janua" in 1460. Guttenberg used none but *wooden* or *cut metallic* types till the year 1462.

Faust gave his daughter in marriage to Schoeffer, the former servant of Guttenberg and himself, and the inventor of *cast metallic type*.

The most ample testimony in favor of Schoeffer is given by Jo. Frid. Faustus, of Aschaffenburg, from papers preserved in his family: —

"Peter Schoeffer of Gernsheim, perceiving his master Faust's design, and being himself ardently desirous to improve the art, found out (by the good providence of God) the method of cutting (*incidendi*) the characters in a *matrix*, that the letters might easily be singly *cast*, instead of being *cut*. He privately *cut matrices* for the whole alphabet; and when he showed his master the letters cast from those matrices, Faust was so pleased with the contrivance that he promised Peter to give him his only daughter Christina in marriage, a promise which he soon after performed. But there were as many difficulties at first with these letters as there had been before with *wooden* ones, the metal being too soft to support the force of the impression; but this defect was soon remedied by mixing the metal with a substance which sufficiently hardened it."

Service with Guttenberg was the means of directing Schoeffer's attention in this line, but it must be admitted that the invention of the latter was by very far the greatest of the series, leaving nothing for future generations but to improve the details of the process.

The first book printed with *cast types* was "Durandi Rationale," in 1459; they seem, however, to have had only *one size* of *cast* letters, all the larger characters which occur being *cut types*, as it plainly appears by an inspection of the book. Faust and Schoeffer continued to print a considerable number of works till 1466. They took more impressions on *vellum* than on *paper* in their earliest works, which was the case with their Bibles and Tully's Offices. This was soon inverted; for when *paper* was introduced, they took but few impressions on *vellum*, which were more for curiosities than for general use. How long Faust lived is uncertain; but, in 1471, we find that Schoeffer was in partnership with Conrad Henlif and a kinsman of his master Faust. Faust and Schoeffer printed the

"Codex Psalmorum" (with *cut* types), in 1457, now in Imperial Library, Vienna.
"Durandi Rationale," 1459, Earl of Pembroke's Library, England.
"Catholicon Januensis," 1460, Royal Library, France.
Livy printed "Du Fresnoy," 1460.
First Bible completed, 1460.
Latin Bible, 1462; Royal Library, France.
Greek characters first used, 1465.
"Cicero de Officiis," 1465.
Tully's Offices, 1465-66, Bodleian and other libraries.
Roman characters at Rome, 1467.
Caxton sets up a press at London, 1471.
"De Civitate Dei," 1473.
Æsop's Fables, by Caxton, first book with numbered pages, 1474.
Aldus cast the Greek alphabet and printed a Greek book, 1476.
Aldus introduced italics, 1476.
"The Pentateuch" in Hebrew, 1482.
Homer in folio, by Demetrius of Florence, 1488.
The "Complutensian Polyglot" of Cardinal Ximenes, in 1517

The exact conformity of different copies of the book taken by Faustus for sale in Paris gave rise to the report of his being in league with Satan, and was the origin of the popular story of his attendant demon.

The Mentz printers, in order that the art might not be divulged, administered an oath of secrecy to all whom they employed; this appears to have been strictly adhered to until the year 1462, at which period the city was sacked and plundered by Archbishop Adolphus of Nassau; its former rights and franchises were also abolished. Amid the consternation occasioned by this extraordinary event, the workmen of the Mentz press, considering their oath of fidelity no longer binding, spread themselves in different directions. By this circumstance the hitherto great mystery was rapidly carried through a considerable portion of Europe; and the places which received it early, after some time commenced a contention for the merit of the discovery.

Laurentius Zanssen, surnamed Koster, was born in Haarlem about 1370, and died 1440. His claim to be the inventor of separate wooden types rests upon the testimony of Adrian Young, rector of the Latin School of Haarlem about 1570. It is said that he tied with string his form of separate wooden types. It is more probable, from some existing specimens, that he sometimes cut blocks of a few words or lines to print portions of a page or add inscriptions to cuts.

A claim has also been put in for John Mentilius of Strasburg.

Janson of France, an engraver of coins and medals, about 1458, seems to have observed the process and subsequently practiced it in Venice, where he published the "Decor Puellarum" and "Gloria Mulierum," in 1471. He determined the form and proportions of the present Roman character.

It may be mentioned that, as at first practiced in Europe, sheets were printed on but one side and the backs of the pages pasted together. At first, also, spaces were left for the illuminated capital letters, which were put in by hand.

The art was carried to France in 1469; to Italy, in 1465; to Spain, in 1477; to England by Caxton, in 1474.

Italy soon took the lead, and long kept it, Venice being the headquarters. In the editions published in the sixteenth century, one half were Italian, and one half of these were Venetian; one seventeenth were English.

In Venice, during the Turkish war of 1563, newspapers first made their appearance. The "Gazette de France" was commenced in 1631. Newspapers were fairly established in England after the decapitation of Charles I.

The forms of the old printers were generally either large or small folios, or at least quartos; the lesser sizes were not in use. The leaves were without running-title, direction-word, number of pages, or divisions into paragraphs. The character itself was a rude old Gothic mixed with Secretary, designed on purpose to imitate the handwriting of those times. The words were printed so close to one another that it was difficult and tedious to be read even by those who were used to manuscripts and to this method, and often lead the inattentive reader into mistakes. Their orthography was various and often arbitrary, disregarding method. They had very frequent abbreviations, which in time grew so numerous and difficult to be understood, that there was a necessity for writing a book to teach the manner of reading them. Their periods were distinguished by no other points than the double or single one, that is, the colon and full-point; but they a little after introduced an oblique stroke, thus /, which answered the purpose of our comma. They used no capital letters to begin a sentence, or for proper names of men or places. They left blanks for the places of titles, initial letters, and other ornaments, in order to have them supplied by the illuminators, whose ingenious art, though in vogue before and at that time, did not long survive the masterly improvements made by the printers in this branch of their art. The name of the printer, place of his residence, etc., etc., were either wholly neglected or put at the end of the book, not without some pious ejaculation or doxology. The date was likewise omitted or involved in some cramped circumstantial period, or else printed either at full length or by numerical letters, and sometimes partly one and partly the other; thus, one Thousand CCCC and lxxxiii, etc.; but all of them at the end of the book. There was no variety of characters, no intermixture of Roman and italic; these are of later invention; but their pages were continued in a Gothic letter of the same size throughout. They printed but few copies at once, for 200 or 300 were then esteemed a large edition.

Catchwords at the foot of pages were first used at Venice by Vindeline de Spori. They have but lately been abolished.

Signatures to sheets were used by Zorat in Milan in 1470.

The first press in America was in Mexico. The "Manual for Adults" was printed on it in 1550 by Juan Cromberger, who was probably the first printer in America. The second press was at Lima, in 1586. The press at Cambridge, Massachusetts, was established in January, 1639, by Stephen Daye. It still exists as the "University Press," and at that establishment this Dictionary has the honor to be set up. The Faculty of Harvard College was censor till 1662, when "licensers of the press" were appointed. In 1755 the press was free. A Psalter in the English and Indian languages was printed at the "University Press" in 1709.

A printing-press was established in New London, Conn., in 1709; the first printing-press in Turkey was brought from Paris by Mohammed Effendi, in 1721; the first press in Annapolis, Md., was in 1726; Williamsburg, Va, 1729; Charleston, S. C., 1730; Newport, R. I., 1732; Halifax, N. S., 1751; Newbern, N. C., 1755; Portsmouth, N. H., 1756; Savannah, Ga., 1763; Quebec, Canada, 1764. The first press west of the Alleghany range was in Cincinnati, 1793. The first press west of the Mississippi, in St. Louis, 1808.

Stereotyping was invented by William Ged of Edinburgh, in 1725; inking-rollers, by Nicholson; *composition* inking-rollers, by Donkin and Bacon of London, in 1813.

The Roman alphabet is used for the body of printed matter in English books and newspapers, though hundreds of types differing from the Roman are used for special purposes, as the titles of books and in displayed advertisements. See LETTER; FONT.

The compositor at work on ordinary printed matter has a pair of cases for his Roman letter and another pair, or a double case, for italic. (See CASE.) In picking up the letters he works without reference to the face of the type, but is guided entirely by the *nicks*, assuming always that his case is not *foul*, that is, does not have letters in the wrong boxes.

In putting the type in his *stick*, he places it so that the nicked end shall be down and away from him. Each letter is held by the thumb of the left hand until another letter or space is placed beside it. In reading from type the letters are of course inverted.

At the end of the line, if the words do not fill the stick they are made to do so by wider spacing, or the ordinary spaces are replaced by thinner ones, so that another word or syllable can go in. This is called justifying.

When the stick is filled, the matter is lifted out on to a galley for proving. When the proof has been read, the type is *made up* into pages or columns, *locked up* in a *chase*, and is then *ready for the press*, or for *stereotyping* or *electrotyping*.

When the edition has been printed the type is said to be *dead*, and is ready for distribution. A compositor will *distribute matter* from three to four times as fast as he can *set* it.

Electrotype or stereotype plates are used instead of type when the edition is so large that wear of type would amount to more than the cost of plates, when it is desired to preserve the plates for a future edition, and sometimes for other reasons. Among

Cost of One Ream and of 100 Sheets of Paper, Weight per Ream and Cost per Pound being given, from 12 to 150 pounds per Ream, and at from 16 to 35 Cents per Pound.

[The upper figure in each square gives the cost per ream (480 sheets), and the lower figure per 100 sheets. The last column gives the price per half-cent, to assist in calculating the fractions.]

Lbs. per Ream.	16c.	17c.	18c.	19c.	20c.	21c.	22c.	23c.	24c.	25c.	26c.	27c.	28c.	29c.	30c.	31c.	32c.	33c.	34c.	35c.	½c.
12	1.92 .40	2.04 .43	2.16 .45	2.28 .48	2 40 .50	2.52 .53	2.64 .55	2.76 .58	2.88 .60	3.00 .63	3.12 .65	3.24 .68	3.36 .70	3.48 .75	3.60 .76	3.72 .78	3.84 .80	3.96 .83	4.08 .86	4.20 .88	.06 .01
14	2.24 .47	2.38 .50	2.52 .53	2.66 .55	2.80 .58	2.94 .61	3.08 .65	3.22 .67	3.36 .70	3.50 .73	3.64 .76	3.78 .79	3.92 .82	4.06 .85	4.20 .88	4.34 .90	4.48 .93	4.62 .96	4.76 .99	4.90 1.02	.07 .01
16	2.56 .53	2.72 .57	2.88 .60	3.04 .63	3 20 .67	3.36 .70	3.52 .73	3.68 .77	3.84 .80	4.00 .83	4.16 .87	4.32 .90	4.48 .93	4.64 .97	4.80 1.00	4.96 1.03	5.12 1.06	5.28 1.10	5.44 1.13	5.60 1.17	.08 .02
18	2.88 .60	3.06 .64	3.24 .68	3.42 .71	3.60 .75	3.78 .78	3.96 .83	4.14 .86	4.32 .90	4.51 .94	4.68 .98	4.86 1.01	5.04 1.05	5.22 1.09	5.40 1.13	5.58 1.16	5.76 1.20	5.94 1.24	6.12 1.28	6.30 1.31	.09 .02
20	3.20 .67	3.40 .71	3.60 .75	3 80 .79	4.00 .83	4 20 .88	4.40 .92	4.60 .96	4.80 1.00	5.00 1.04	5.20 1.08	5.40 1.13	5.60 1.17	5.80 1.21	6.00 1.25	6.20 1.30	6.40 1.33	6.60 1.38	6.80 1.42	7.00 1.46	.10 .02
22	3.52 .73	3.74 .78	3.96 .83	4.18 .87	4.40 .93	4.62 .97	4 84 1.02	5.06 1.06	5.28 1.10	5.50 1.15	5.72 1.20	5.94 1.24	6.16 1.28	6.38 1.33	6.60 1.38	6.82 1.42	7 04 1.47	7.26 1.51	7.48 1.56	7.70 1.60	.11 .02
24	3 84 .80	4 08 .85	4.32 .90	4.56 .95	4 80 1.00	5.04 1.05	5 28 1.10	5.52 1.15	5 76 1 20	6.00 1 25	6.24 1.30	6.48 1.35	6.72 1.40	6.96 1.45	7.20 1.50	7.44 1.55	7.68 1.60	7.92 1.65	8.16 1.70	8.40 1.75	.12 .03
26	4 16 .87	4.42 .92	4.68 .97	4.94 1.03	5 20 1.08	5.46 1.14	5.72 1.19	5.98 1.25	6 24 1.30	6.50 1.35	6.76 1.41	7.02 1.46	7.28 1.52	7.54 1.58	7.80 1.63	8.06 1.68	8.32 1.73	8.58 1.78	8.84 1.84	9.10 1.90	.13 .03
28	4.48 .93	4.76 .99	5.04 1.05	5.32 1.11	5 60 1.17	5.88 1.23	6.16 1 28	6.44 1.34	6 72 1.40	7 00 1.46	7.28 1.52	7.56 1.58	7.84 1.63	8.12 1.69	8.40 1.75	8.68 1.81	8.96 1.87	9.24 1.93	9.52 1.98	9.80 2.04	.14 .03
30	4.80 1.00	5.10 1.07	5 40 1.13	5.70 1.19	6.00 1.25	6.30 1.31	6.60 1.37	6 90 1.44	7 20 1.51	7.50 1.56	7.80 1.63	8.10 1.69	8.40 1.75	8.70 1.81	9.00 1.83	9.30 1.94	9.60 2.00	9.90 2.06	10.20 2.13	10.50 2.19	.15 .03
32	5.12 1.07	5.44 1.13	5.76 1.20	6.08 1.27	6.40 1.33	6.72 1.40	7.04 1 47	7.36 1.53	7.68 1.60	8.00 1.67	8.32 1.73	8.64 1.80	8.96 1.87	9.28 1.93	9.60 2.00	9.92 2.07	10.24 2.13	10.56 2.20	10.88 2.27	11.20 2.33	.16 .03
34	5.44 1.14	5.78 1.20	6.12 1.28	6.46 1.35	6 80 1.42	7.14 1.49	7.48 1.56	7 82 1.63	8.16 1.70	8.50 1.77	8.84 1.84	9.18 1.91	9.52 1.98	9.86 2.05	10.20 2.13	10.54 2.20	10.88 2.27	11.22 2.34	11.56 2.41	11.90 2.48	.17 .04
35	5.60 1.17	5.95 1.24	6.30 1.31	6 65 1.39	7.00 1.46	7 35 1 53	7 70 1.60	8 05 1 68	8.40 1.75	8 75 1.82	9.10 1.90	9.45 1.97	9.80 2.04	10.15 2.12	10.50 2.19	10.85 2.26	11.20 2.33	11.55 2.41	11.90 2.48	12.25 2.55	.18 .04
36	5 76 1.20	6 12 1.28	6.48 1.35	6.84 1.43	7.20 1.50	7.56 1.58	7.92 1.65	8 28 1.73	8.64 1.80	9 00 1.88	9.36 1.95	9.72 2.03	10.08 2.10	10.44 2.18	10.80 2.25	11.16 2.33	11.52 2.40	11.88 2.48	12.24 2.55	12.60 2.63	.18 .04
38	6 08 1.27	6.46 1.35	6.84 1.43	7.22 1.50	7.60 1.58	7.98 1 66	8.36 1.74	8.74 1.83	9.12 1.90	9.50 1 98	9.88 2.06	10.26 2.14	10.64 2.22	11.02 2.29	11.40 2.38	11.78 2.45	12.16 2.53	12.54 2.61	12.92 2.69	13.30 2.77	.19 .04
40	6 40 1.33	6.80 1.42	7.20 1.50	7.60 1.58	8.00 1.67	8.40 1.75	8 80 1 83	9.20 1.92	9.60 2.00	10 00 2 08	10.40 2.17	10.80 2.25	11.20 2.33	11.60 2.42	12.00 2.50	12.40 2.58	12.80 2.67	13.20 2.75	13.60 2.83	14.00 2.92	.20 .04
42	6.72 1.40	7 14 1.49	7.56 1.58	7.98 1.66	8.40 1 75	8.82 1.84	9.21 1.93	9.66 2 01	10.08 2.10	10.50 2.19	10.92 2.28	11.34 2.36	11.76 2.45	12.18 2.54	12.60 2.63	13.02 2.71	13.44 2.80	13.86 2.89	14.28 2.97	14.70 3.06	.21 .04
44	7.04 1.47	7.48 1.56	7.92 1.65	8.36 1.74	8.80 1.83	9.24 1.92	9.68 2.02	10 12 2.11	10.56 2.20	11.00 2.29	11.44 2.38	11.88 2.48	12.32 2.57	12.76 2.66	13.20 2.75	13.64 2.84	14.08 2.93	14.52 3.03	14.96 3.12	15.40 3.21	.22 .05
45	7.20 1.50	7 65 1.59	8.10 1 69	8.55 1.78	9.00 1 88	9 45 1 97	9.90 2 06	10 35 2.16	10 80 2.25	11 25 2.34	11.70 2.44	12.15 2.53	12.60 2.63	13.05 2.72	13.50 2.81	13.95 2.91	14.40 3.00	14.85 3.09	15.30 3.19	15.75 3.28	.23 .05
46	7.36 1.33	7.82 1.63	8.28 1.73	8 74 1.82	9.20 1.92	9 66 2 01	10.12 2.11	10 58 2.20	11.04 2.30	11.50 2.40	11.96 2.49	12.42 2.59	12.88 2.68	13.34 2.79	13.80 2.88	14.26 2.97	14.72 3.07	15.18 3.16	15.64 3.26	16.10 3.35	.23 .05
48	7.68 1.60	8.16 1.70	8 64 1.80	9.12 1.90	9.60 2 00	10.08 2 10	10.56 2.20	11.04 2 30	11.52 2.40	12.00 2.50	12.48 2.60	12.96 2.70	13.44 2.80	13.92 2.90	14.40 3.00	14.88 3.10	15.36 3.20	15.84 3.30	16.32 3.40	16.80 3.50	.24 .05
50	8.00 1.67	8.50 1.77	9.00 1.88	9.50 1.98	10 00 2 08	10.50 2.19	11 00 2.29	11.50 2.40	12 00 2 50	12.50 2.60	13.00 2.71	13.50 2.81	14.00 2.92	14.50 3.02	15.00 3.13	15.50 3.23	16.00 3.33	16.50 3.44	17.00 3.54	17.50 3.65	.25 .05
52	8.32 1.73	8.84 1.84	9 36 1.95	9.88 2.06	10.40 2 17	10.92 2 28	11.44 2.38	11.96 2.49	12.48 2.60	13.00 2 71	13.52 2.82	14.04 2.93	14.56 3.03	15.08 3.14	15.60 3.25	16.12 3.36	16.64 3.47	17.16 3.57	17.68 3.68	18.20 3.79	.26 .05
54	8.64 1 80	9.18 1.91	9.72 2.03	10.26 2 14	10.80 2 25	11 34 2 36	11.88 2.48	12 42 2 59	12.96 2.70	13.50 2 81	14.04 2.93	14.58 3.04	15.12 3.15	15.66 3.26	16.20 3.37	16.74 3.49	17.28 3.60	17.82 3.71	18.36 3.83	18.90 3.94	.27 .06
55	8.80 1.83	9.35 1.95	9.90 2.06	10.45 2 18	11.00 2 29	11.55 2.41	12.10 2.52	12 65 2.63	13.20 2 75	13 75 2 87	14.30 2.98	14.85 3.09	15.40 3.21	15.95 3.32	16.50 3.44	17.05 3.55	17.60 3.67	18.15 3.78	18.70 3.90	19.25 4.01	.28 .06
56	8.96 1.87	9 52 1.99	10 08 2.10	10.64 2.22	11.20 2.33	11.76 2.45	12.32 2 57	12 88 2 68	13.44 2.80	14 00 2 92	14.56 3.03	15.12 3.15	15.68 3.27	16.24 3.38	16.80 3.45	17.36 3.62	17.92 3.73	18.48 3.85	19.04 3.97	19.60 4.08	.28 .06
58	9 28 1.93	9 86 2 05	10.44 2.18	11 02 2.30	11 60 2.42	12.18 2.54	12 76 2 66	13.34 2.78	13.92 2 90	14.50 3.02	15.08 3.14	15.66 3.26	16.24 3.38	16.82 3.50	17.40 3.63	17.98 3.75	18.56 3.87	19.14 3.99	19.72 4.11	20.30 4.23	.29 .06
60	9.60 2.00	10 20 2.13	10 80 2.25	11 40 2 38	12.00 2.50	12.60 2 63	13.20 2.75	13 80 2.88	14.40 3.00	15 00 3.13	15.60 3.25	16.20 3.38	16.80 3.50	17.40 3.63	18.00 3.75	18.60 3.88	19.20 4.00	19.80 4.13	20.40 4.25	21.00 4.38	.30 .06
65	10.40 2 17	11.05 2.30	11.70 2.44	12 35 2.58	13.00 2 71	13.65 2 84	14.30 2 98	14.95 3.12	15.60 3 25	16.25 3.39	16.90 3.52	17.55 3.66	18.20 3.79	18.85 3.93	19.50 4.06	20.15 4.20	20.80 4.33	21.45 4.47	22.10 4.60	22.75 4.74	.33 .07
70	11.20 2.33	11.90 2.48	12.60 2.63	13.30 2 77	14 00 2.92	14.70 3.06	15 40 3.21	16.10 3.35	16 80 3.50	17 50 3.65	18.20 3.80	18.90 3.94	19.60 4.08	20.30 4.23	21.00 4.38	21.70 4.52	22.40 4.67	23.10 4.82	23.80 4.96	24.50 5.10	.35 .07
75	12.00 2.50	12.75 2 66	13.50 2.81	14.25 2 96	15.00 3.13	15 75 3 28	16 50 3.44	17.25 3.59	18 00 3 75	18.75 3 91	19.50 4.06	20.25 4.22	21.00 4.38	21.75 4.53	22.50 4.69	23.25 4.84	24.00 5.00	24.75 5.16	25.50 5.31	26.25 5.47	.38 .08
80	12.80 2.67	13 60 2 83	14 40 3 00	15 20 3.17	16.00 3.33	16.80 3.45	17.60 3 67	18 40 3.83	19.20 4 00	20.00 4 17	20.80 4.33	21.60 4.45	22.40 4.67	23.20 4.83	24.00 5.00	24.80 5.17	25.60 5.33	26.40 5.45	27.20 5.67	28.00 5.83	.40 .08
85	13.60 2.83	14.45 3.01	15 30 3.19	16 15 3.37	17.00 3.50	17.85 3.72	18 70 3.90	19 55 4.07	20 40 4.25	21.25 4.43	22.10 4.60	22.95 4.78	23.80 4.96	24.65 5.14	25.50 5.31	26.35 5.50	27.20 5.67	28.05 5.83	28.90 6.01	29.75 6.19	.43 .09
90	14 40 3.00	15 30 3 19	16 20 3 38	17.10 3.56	18.00 3.76	18 90 3 94	19 80 4.13	20.70 4 31	21.60 4 50	22 50 4 69	23.40 4.88	24.30 5.06	25.20 5.25	26.10 5.44	27.00 5.63	27.90 5.81	28.80 6.00	29.70 6.19	30.60 6.38	31.50 6.56	.45 .09
95	15.20 3.17	16.15 3.37	17.10 3.56	18.05 3.76	19 00 3 96	19 95 4.16	20.90 4.35	21 85 4 55	22 80 4.75	23.75 4.95	24.70 5.15	25.65 5.34	26.60 5.54	27.55 5.74	28.50 5.94	29.45 6.14	30.40 6.33	31.35 6.53	32.30 6.73	33.25 6.93	.48 .10
100	16 00 3.33	17.00 3.54	18.00 3 75	19.00 3.96	20 00 4.17	21.00 4.38	22 00 4 58	23 00 4.79	24 00 5.00	25 00 5 21	26.00 5.42	27.00 5.63	28.00 5.83	29.00 6.04	30.00 6.25	31.00 6.46	32.00 6.67	33.00 6.88	34.00 7.08	35.00 7.29	.50 .10
110	17.60 3.67	18 70 3 90	19.80 4.13	20.90 4.35	22.00 4 58	23 10 4.81	24.20 5 04	25.30 5.27	26.40 5 50	27.50 5 73	28.60 5.96	29.70 6.19	30.80 6.42	31.90 6.65	33.00 6.88	34.10 7.10	35.20 7.33	36.30 7.56	37.40 7.79	38.50 8.02	.55 .12
120	19.20 4 00	20 40 4 25	21.60 4 50	22.80 4.75	24.00 5.00	25.20 5.25	26.40 5.50	27.60 5 75	28 80 6.00	30.00 6 25	31.20 6.50	32.40 6.75	33.60 7.00	34.80 7.25	36.00 7.50	37.20 7.75	38.40 8.00	39.60 8.25	40.80 8.50	42.00 8.75	.60 .13
130	20.80 4.33	22 10 4 60	23.40 4.88	24.70 5.15	26.00 5.42	27.30 5.69	28 60 5 96	29 90 6 23	31.20 6.50	32.50 6 77	33.80 7.04	35.10 7.31	36.40 7.58	37.70 7.85	39.00 8.12	40.30 8.40	41.60 8.67	42.90 8.94	44.20 9.21	45.50 9.48	.65 .14
140	22.40 4.67	23.50 4.96	25 20 5.25	26 60 5 54	28.00 5 83	29.40 6.13	30 80 6.42	32 20 6 71	33.40 7.00	35.00 7.29	36.40 7.58	37.80 7.88	39.20 8.17	40.60 8.46	42.00 8.75	43.40 9.04	44.80 9.33	46.20 9.63	47.60 9.92	49.00 10.21	.70 .15
150	24.00 5.00	25 50 5 31	27.00 5 63	28.50 5 94	30 00 6.25	31 50 6 56	33.00 6 88	34.50 7.19	36.00 7.50	37.50 7.81	39.00 8.13	40.50 8.44	42.00 8.75	43.50 9.06	45.00 9.38	46.50 9.69	48.00 10.00	49.50 10.31	51.00 10.63	52.50 10.94	.75 .16
	16c.	17c.	18c.	19c.	20c.	21c.	22c.	23c.	24c.	25c.	26c.	27c.	28c.	29c.	30c.	31c.	32c.	33c.	34c.	35c.	½c.

book-printers it is often said that an edition of 5,000 copies will warrant the expense of stereotyping, and less than that number will not pay for publication.

b. (*Plate-printing.*) Taking impressions from engraved plates. See COPPERPLATE-PRINTING.

c. (*Stone.*) See LITHOGRAPHY; LITHOGRAPHIC PRESS; PHOTOLITHOGRAPHY.

d. (*Fabric.*) See CALICO-PRINTING.

e. (*Embossed.*) See PRINTING FOR THE BLIND.

f. (*Color.*) See CHROMATIC PRINTING; CHROMOLITHOGRAPHY.

An American invention has been made public for producing pictorial effects by the use of movable metallic types, cast like ordinary printing types, and bearing upon their faces different devices, which, by their combination, produce the desired effect. The types are each $\frac{1}{32}$ of an inch square, their surfaces either plain, black, or lined in various directions and degrees of fineness. It is probably rather more ingenious than useful, and approximates the appearance of a canvas pattern for needlework.

Fasoli's *stigmatypy* consists in using only the full-point of different sizes cast upon the same body. The variations in shade and the whole effect is produced, as in ordinary stipple engraving, according to the proximity of the points.

g. Printing in gold is done in one of two ways: —

1. The impression is taken in a mixture of varnish, burnt umber, and gold size. Upon this gold-leaf is laid and lightly pressed. When sufficiently dry, the superfluous gold is rubbed, leaving the gilded letters.

Bronze-powder is used for inferior printing

2. Whittaker's method. The stereotype-plate is placed on a hot metal block on the bed of the press. The gold-leaf is laid on the face of the metallic page. The paper or vellum is placed on the tympan, having been previously sifted over with dried glair of egg and resin. The tympan is turned down and the pressure maintained a little longer than usual.

2. (*Photography.*) The obtaining of *positive* prints from the exposure of sensitized paper beneath a photographic *negative* to the sun's rays. First performed by Fox Talbot. See PHOTOGRAPHY.

Quantity of Paper required for 1,000 *Copies of a Book, and the Number of Pages to Forms of various Sizes.*

Forms.	Paper.		4to Pages.	8vo Pages.	12mo Pages.	18mo Pages.	32mo Pages.
	R'ms.	Q'res.					
1	1	2	8	16	24	36	64
2	2	4	16	32	48	72	128
3	3	6	24	48	72	108	192
4	4	8	32	64	96	144	256
5	5	10	40	80	120	180	320
6	6	12	48	96	144	216	384
7	7	14	56	112	168	252	448
8	8	16	64	128	192	288	512
9	9	18	72	144	216	324	576
10	11		80	160	240	360	640
11	12	2	88	176	264	396	701
12	13	4	96	192	288	432	768
13	14	6	104	208	312	468	832
14	15	8	112	224	336	504	896
15	16	10	120	240	360	540	960
16	17	12	128	256	384	576	1024
17	18	14	136	272	408	612	
18	19	16	144	288	432	648	
19	20	18	152	304	456	684	
20	22		160	320	480	720	
21	23	2	168	336	504	756	
22	24	4	176	352	528	792	
23	25	6	184	368	552	828	
24	26	8	192	384	576	864	
25	27	10	200	400	600	900	
26	28	12	208	416	624	936	
27	29	14	216	432	648	972	
28	30	16	224	448	672	1008	
29	31	18	232	464	696	1044	
30	33		240	480	720		
31	34	2	248	496	744		
32	35	4	256	512	768		
33	36	6	264	528	792		
34	37	8	272	544	816		
35	38	10	280	560	840		
36	39	12	288	576	864		
37	40	14	296	592	888		
38	41	16	304	608	912		
39	42	18	312	624	936		
40	44		320	640	960		
41	45	2	328	656	984		
42	46	4	336	672	1008		
43	47	6	344	688			
44	48	8	352	704			
45	49	10	360	720			
46	50	12	368	736			
47	51	14	376	752			
48	52	16	384	768			
49	53	18	392	784			
50	55		400	800			

Official Classification of the Class of Printing.

KINDS OF PRINTING.

Albertype.
Anastatic.
Aquatint.
Autography.
Autotypography.
Bas-relief.
Block.
Bronze
Calico (fabric).
Ceramic.
Chemitypy.
Chromatic.
Chromolithographic.
Electro-magnetic.
Embossed typography (blind).
Embossing (color).
Flock.
Fugitive.
Galvanoglypty.
Galvanography.
Glass.
Globular surface.
Helioehromy.
Heliotypy.
Hieroglyphic.
Intaglio.
Letterpress.
Lithographic.
Marbling.
Mezzotinto.
Music.
Nature.
Offset.
Paneiconography.
Paper-hanging.
Phonotypography.
Photogalvanographic.
Photographic.
Photo-relief.
Phototypography.
Photozincography.
Plate.
Spool.
Stigmatypic.
Telotype.
Thermography.
Transfer.
Warp.
Xylographic.
Yarn.
Zincography.

SURFACES.

Anaglyptograph.
Chromatic type.
Convex type surfaces.
Dies.
Ectypography.
Electrotypes.
Engraved cylinders.
Engraved plates.
Etched.
Galvanoplastic.
Glyphography.
Graphotype.
Logotypes.
Movable types.
Metallic (by chemicals and electricity).
Perforated plates.
Photoglyptic.
Phraseotypes.
Rubber stereotypes.
Rubber type.
Sectional plates.
Stereotypes.
Stone.
Stone cylinder.
Tapered type.
Wood carvings.
Zinc cylinders.

PRESSES.

Oscillating.

Oscillating bed and platen.
Oscillating bed, stationary platen.
Oscillating platen, stationary bed.

Reciprocating.

Addressing-machines.
Block.
Branding-stamps.
Card-presses.
Copying-presses.
Embossing-presses.
Fluidic impression.
Lever-press.
Perfecting.
Perforating-stamps.
Reciprocating bed and platen.
Reciprocating platen, stationary bed.
Stationary platen and reciprocating bed.
Type-writing.

Rotary.

Copying-press.
Many-impression cylinders, horizontal form.
Many-type cylinders, common axis.
Numbering-machines.
Paging-machine.
Perforating.
Prismatic form, rotating impression-cylinder.
Reciprocating cylinder and reciprocating bed.
Reciprocating cylinder, stationary bed.
Revolving type-cylinder.
Rotating cylinder, reciprocating bed.
Rotating cylinder, rotating bed.
Segmental cylinder and bed.
Segmental cylinder (type on flat side).
Single type-cylinder, double feed.
Single type-cylinders, many-impression cylinders.
Stop-cylinder.
Vertical type-cylinder, radially arranged impression-cylinders.
Vibrating cylinder, reciprocating bed.

ADJUNCTS.

Blankets.
Bodkins.
Chases.
Composing-sticks.
Copy-holders.
Damping.
Delivering.
Drop-rollers.
Feeding.
Fly-frames.
Folding-machines.
Friskets.
Galley-rests.
Galleys.
Grippers.
Imposing-stone.
Inking { Ball. / Pelts. / Roller.
Lapping.
Leads.
Mallet.
Mitering-machines.
Offsetting-blankets.
Palette-knife.
Quads, quadrats.
Quoins.
Registering.
Reglets.
Rule-cutters.
Rules.
Scrapers.
Shooting-stick.
Slugs.
Spaces.
Stereotype-plate holders.
Sticks (side, head, and foot).
Tympans.
Type-cases.
Type-casting.
Type composing and distributing.
Type-cutting.
Type-gage.
Type-rubbing.

See under the following heads: —

Accented letters.
Addressing-machine.
Agate.
Alley.
Anastatic printing.
Antique.
Apostrophe.
Ascending-letter.
Backing.
Bank.
Bank-note.
Bat-printing.
Beard.
Bed.
Bevel.
Bite.
Blackleading-machine.
Blanket.
Block.
Block-printing.
Board-rack.
Bodkin.
Body.
Book.
Bourgeois.
Box.
Brace.
Bracket.
Brass rule.
Brayer.
Breve.
Brevier.
Cahier.
Calico-printing.
Canon.
Card-press.
Caret.
Carriage.
Case.
Ceramic printing.
Chase.
Chromatic printing.
Clay-process.
Color-printing.
Column-rule.
Composing-frame.
Composing-machine.
Composing-stand.
Composing stick.
Condensed letter.
Copper-faced type.
Copperplate press.
Copy-holder.
Crochet-type.
Crotchet.
Cutting-line.
Cylinder printing-press.
Dabber
Damping-machine.
Dead matter.
Descending letter.
Diamond.
Dipping-pan.
Dip-roller.
Distributing-machine.
Distributing-roller.
Double-cylinder press.
Double letter.
Drum.
Ductor.
Duodecimo (12mo).
Eighteenmo (18mo).
Elastic type.
Electrotype.
Em.
Embossed typography.
Emerald.
English.
Extended letter.
Face.
Feeding-apparatus.
Floating-plate.
Fly.
Fly-board.
Folio.
Font.
Foot-stick.
Form.
Forties.
Forty-eights (48's).
Frame.
Frisket.
Furniture.
Gage paper-cutter.
Gage. Printer's
Galley.
Galley-roller.
Gallows.
Gold-printing.
Gold-size.
Great primer.
Grippers.
Guide.
Guillotine-cutter.
Gutta-percha plate.
Gutter.
Gutter-snipe.
Hair-line.
Hat-tip press.
Head-stick.
Horn-book.
Horse.
Imposing.
Imposing-stone.
Inferior letter.
Ink-cylinder.
Ink-fountain.
Inking-trough.
Ink-roller.
Ink-slice.
Inner form.
Inset.
Italic.
Kern.
Lead.
Lead-cutter.
Leader.
Lean face.
Letter.
Letter-board.
Letter-case.
Letterpress-printing.
Ligature.
Lithographic press.
Live matter.
Logotype.
Long primer.
Lower case.
Mailing-machine.
Manifold writing-book.
Matrix.
Matter.
Medium.
Metal furniture.
Minion.
Minionette.
Miter-box.
Mitering-machine.
Music-printing.
Music-type.
Nature-printing.
Newspaper folding-machine.
Nippers.
Nonpareil.
Numbering-machine.
Octavo (8vo).
Offcut.
Oil-cloth printing.
Outer form.
Overlay.
Page-gage.
Paging-machine.
Paragon.
Paste-points.
Pearl.
Peel.
Perfecting-press.
Photo-mechanical printing.
Pica.
Pie.
Pigment-printing.
Planer.
Platen.
Plate-printing machine.
Pompet.
Porcelain.
Porcelain-printing.
Postage-stamp.
Poster.
Pottery-printing.
Press-printing.
Primer.
Printing for the blind.
Printing-frame.
Printing in colors.
Printing in gold.
Printing-ink.
Printing-machine.
Printing. Pictorial
Printing-press.
Printing-roller.
Printing-telegraph.
Printing-wheel.
Printing-yarn.
Proof.
Quadrat (quad).
Quarto (4to).
Quoin.
Raising.
Register.
Register-point.
Reglet.
Revise.
Ribbon for hand-stamps.
Roller-mold.
Roller-printing.
Rounce.
Ruby.
Rule.
Scraper.
Script.
Setting-rule.
Shooting stick
Signature.
Slip
Small pica.
Sorts.
Space.
Space-line.
Space-rule
Stereotyping.
Stereotyping-machine.
Stick
Superior.
Supply-roller.
Surface-printing.
Tape.
Thirty-twos (32's).
Ticket-printing.
Topical coloring.
Transfer-printing
Turtle.
Twelvemo (12mo).
Twenty-fours (24's).
Tympan.
Type.
Type-distributing machine.
Type-setting machine.
Type-writing machine.
Underlay.
Vibrating roller.
Wetting-machine.
White-line.
Yarn-printing machine

Print'ing-bod'y. (*Pottery.*) A piece of ware prepared for being printed.

Print'ing for the Blind. This is a French invention. For it we are indebted to Valentine Haüy, who, in 1784, produced works in relief letters at Paris. He took the idea from a map in relief, the invention of a German. He adopted a form substantially similar to the Roman letters. The Academy of Sciences reported in its favor, a school was established, exhibitions took place before Louis XVI. For want of energy the institution languished until Dr. Guillié took charge in 1814.

The first book in relief in the English language was printed by Dr. Gall of Edinburgh, in 1827.

The Bible was printed in Glasgow by Alston, 1848, in raised Roman characters, upper case. It was comprised in nineteen volumes.

Gall's alphabet, Edinburgh, 1826, was a modified Roman, but in the process of simplification attained a certain resemblance to some old characters, among which may be cited the Punic, Oscan, and Greek. He published a book in this character in 1826, and the Gospel of St. John in 1829–34. Gall is regarded as the principal promoter of the art in Britain. He afterward modified the character of his type, and published a number of other books of the New Testament.

The systems of arbitrary characters, or, in other words, the alphabets adapted for the use of those having the faculty of sight, are not necessarily the best adapted for those who depend upon the sensation of touch. Much fruitless labor has been expended upon the matter, and this has been partly owing to the lack of due consultation with the persons who were to benefit by the result. The Illyrian or Sclavonic alphabet was early adopted, owing to its square form, which seemed to render the character easy to distinguish by the touch. The modification of the Roman character adopted by Haüy was modified by Guillié, and since his time various alphabets have been intro-

dueed. which have isolated the pupils of various institutions from each other, as no pupil could read any of the publications of another institntion without mastering the other alphabet.

The system of punctured letters, invented by a blind man, Louis Braille, consists of dots whose differing numbers and arrangement indicate the respective letters. The number of dots varies from 1 to 6, and the variations readily admit of the letters, acceuted vowels, diphthongs, punctuation marks, numerals, etc.

Other arbitrary systems are those of Lucas, Frere, Moon, and Carton. Lucas's, claimed to be the least diffieult to learn of the English systems, and peculiarly adapted for those who are deficicut in delicacy of touch, uses many abbreviations of words and syllables, and is bulky, thirty-six volumes being required to contain the Scriptures, which, in the Bostou alphabet, fill but eight.

Frere's is a phonetic system; in this the Scriptures are embraced in fifteen volumes.

Moon's system, the invention of a blind man, is based on those of Lucas and Frere, resembling the latter in the lines being alternately read from left to right and from right to left, from a supposed motive of convenieuce. The letters are each formed of one or two lines only, by using nine forms turned in different directions. Few abbreviatious are employed.

Carton's system resembles Braille's, the dots being arranged to more nearly resemble Roman letters.

Alston's system consists of a slight modification of the Roman characters.

In America, the system of Mr. J. B. Friedlander has been to some extent employed. The alphabet is Roman capitals of the form known as block-letter. The only existing dictionary of the English langnage in raised letters is printed in this character.

Dr. Howe of Boston, superintendent for many years of the Perkins Institution for the Blind, is the author of the modified lower case Roman alphabet used in the United States. It has, perhaps, no equal amoug all the Europeau systems, and the Jury Report of the English Exposition of 1851 give it a decided preferenee over all other systems known to the jury.

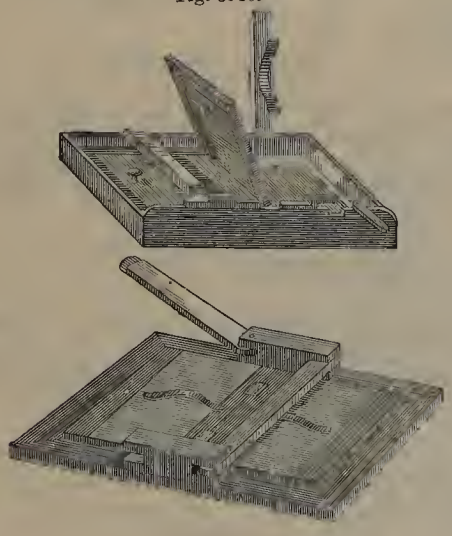
An alphabetic system having lower ease with capitals is also employed in Francc.

Foucault's *printing-frame for the Blind* (French) was exhibited in 1849 and 1851 at the European Expositious, and is substantially as follows: —

The letters of the alphabet executed in relief are fixed on the upper ends of metallic rods made to slide longitudinally in tubes. They are placed on the same plane, in the form of a fan, and at the bottom of each is a small letter agreeing with that on the upper end. The lower ends of all the rods eonverge toward the same spot, and deliver their impressions as called in action at the plaee where the paper is presented. The paper is fed along between each impression, such as to enable the uext impression to be delivered in the proper succession for the sense of the writing. At the end of a liue the paper is shifted upward, and back to the commencement of another line. Foucault, though blind, was successful in business and mechanical enterprises, and was a zealous friend of his afflicted fellow-men.

Johnston's *printing apparatus for the blind* (United States patent, February 19, 1867) differs from the preceding in the mode of operating. The letters are arranged on the ends of cylindrical plungers moving vertically in tubes arranged near the margin of a disk, which is capable of rotation on a vertical axis. Each plunger has a letter in relief for the fingers of the blind, and acts in correspondence with a similar letter, which is to be impressed on the paper. The blind person feels round the disk until he finds the right letter. He then presses the letter and revolves the disk till he hears a click, when a pressure is brought upon the letter at the spot where the paper is presented. Each letter is brought to the same opening to give its impression, and the paper receives two movements, as in Foucault's; one between each letter for the spacing, and another at right angles to the former for the distance between lines. See WRITING-FRAME.

Fig. 3946.



Printing Frames.

Print'ing-frame. (*Photography.*) Also known as a *pressure-frame.* A quadrangular shallow box in which sensitized paper is placed beneath a negative and exposed to the direct rays of the sky or of the sun. Large printing-frames have always a pane of plate-glass in front to support the negative; the latter being laid thereon, and the sensitized paper on the negative. The back is closed, the contact being maintained by buttons and springs. The frame is then inverted, exposing the glass to the light. The back is made in two sections, hinged together, so as to allow examination of the print during exposure without shifting it.

Print'ing-ink. A compound of linseed-oil and lamp or ivory black. The oil is boiled, the lamp-black and sometimes rosin and other ingredients added, and the compound ground. The recipes are various.

Print'ing-ma-chine'. See PRINTING-PRESS; CALICO-PRINTING; COPPERPLATE-PRINTING, etc.

Print'ing-pa'per. Printing-paper includes news, book, and copperplate paper. It is usually bibulous, the oily and viscid ink not being subject to run upon the wet paper. Copperplate-paper is of the quality of *drawing*-paper, minus the sizing. See PAPER.

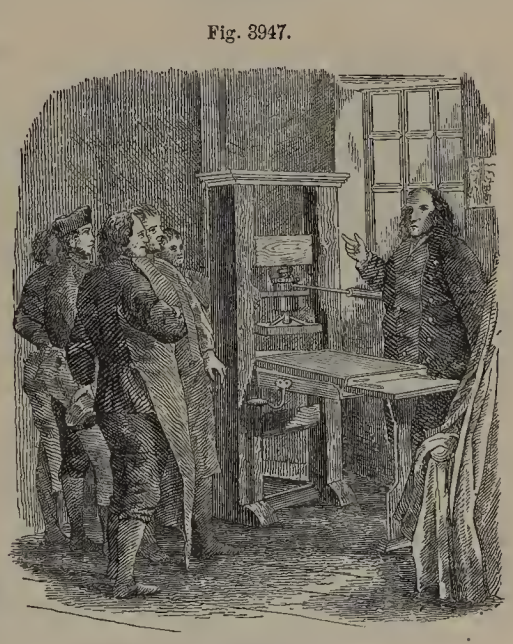
Print'ing-press. A machine to take an impression on paper or parchment from type, electrotype, or stereotype forms, steel or copper plates, lithographic stones, etc.

Presses for book or newspaper printing are broadly divided into *platen* and *cylinder* machines, and the latter again into such as have a flat type-bed reciprocating at the same speed as the surface speed of cylinder, and those which carry the type or printing plates on a revolving cylinder. See list on page 1793.

The first printing-press was a common screw-press with a bed, standards, a beam, a screw, and a movable platen. A contrivance for running the form in and out was afterward added.

Blaew of Amsterdam made a number of improvements in 1620, which entitle him to the rank of the

Fig. 3947.

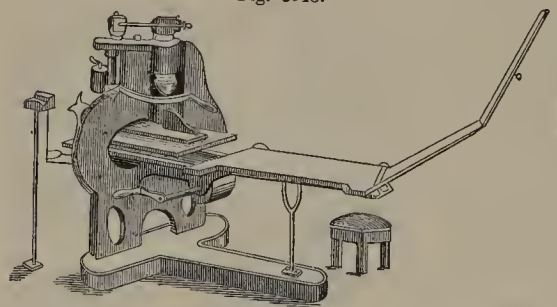


Franklin's Press.

first great improver of the printing-press. His press had a traveling bed, a platen depressed by a screw which was moved by a lever, and by a spring to raise the screw and platen after the delivery of the impression. The condition of the press in the time of the most illustrious printer on record is shown by the annexed cut, which is taken from the original press used by Franklin in London, and now in the museum of the United States Patent-Office. It is still the "Blaew" press, with minor modifications. It operates on the screw principle, the horizontal sweep of the handle rotating the screw which traverses through a nut in the cross-beam above, raising or lowering the platen, the center of whose upper surface has a cup which rests against the lower end of the screw-head; the four corners of the platen being fastened by thongs to the screw-head, so as to give it a certain independence of adjustment, to enable it to fit against the face of the form, that is, to assume parallelism therewith. The form rests on the bed and is secured in position by temper screws. The bed runs in and out on a track; a rack on the under side of the bed being engaged by a pinion on the shaft beneath, which is rotated by a hand-crank. The platen is only large enough to cover one half the bed, and in printing a newspaper it was necessary to screw down the platen on each page, running the bed forward or back between *pulls*.

This may be taken as a sample of the press in use until the advent, late in the eighteenth century, of Lord Stanhope's improved press, which so long maintained its position and has so familiar an appearance. The oscillating hand operates a toggle to

Fig. 3948.



Stanhope Press.

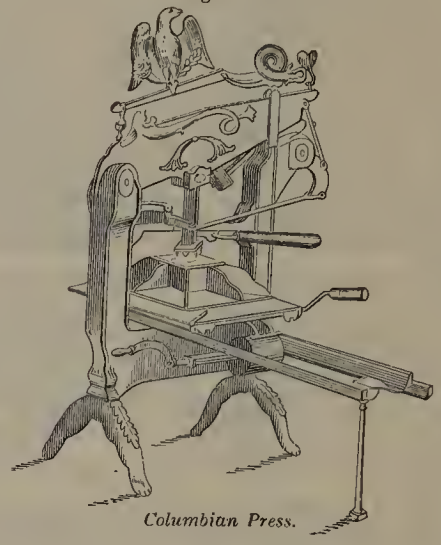
force down the platen upon the paper on the form, and the platen is raised again by a spring when the force is withdrawn. The bed travels on ways, and the frisket is hinged and is so jointed as to lie back in an elevated position when raised for the purpose of withdrawing the sheet, inking the type, and placing a sheet thereon.

The Columbian hand-press was invented by George Clymer of Philadelphia, who completed his invention about 1817. The Columbian press was considered superior to Stanhope's. The power is applied to the platen by a compound lever, consisting of three simple levers of the second order. This press is interesting as being the first important American addition to the art of printing.

Peter Smith's hand-press soon succeeded the Columbian as an American invention, and, in 1829, the Washington press was patented by Samuel Rust. This press has been modified in various ways, and is now the only hand-press much used in the United States for printing large sheets. The pressure is applied by a compound lever acting on a toggle-joint, and the platen is lifted by springs on each side.

In Fig. 3950, *a* is the frame of the press, cast in

Fig. 3949.

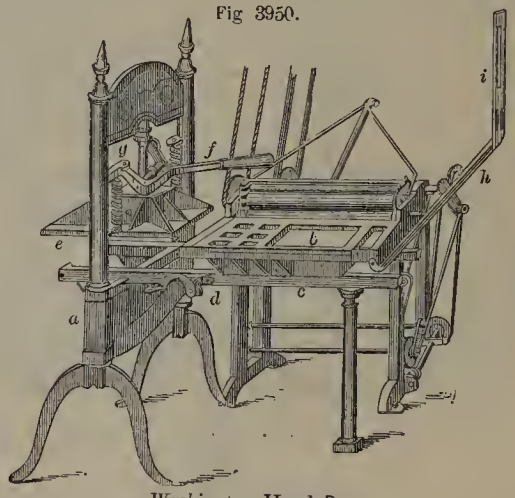


Columbian Press.

sections; *b* is the bed, which slides on track *c*, and is run in and out by turning crank *d*, which has a belt attached to its pulley or *rounce*; *e* is the platen, *f* the handle or bar (sometimes called *devil's tail*), and *g* the toggle. Tympan *h* and frisket *i* are held up by the nature of their hinges, which allow only a certain amount of swing.

An automatic inking action, shown in the cut, was some time since introduced into hand-presses, whereby the inking-roller is operated by a weight raised by the *pull* of the pressman in delivering an

Fig 3950.



Washington Hand-Press.

impression. The descent of the weight draws the roller over the type and returns it to the inking-table while the pressman is placing another sheet upon the *tympan* and folding down the *frisket*.

The parts of a hand-press are: —

Bar; the lever by which pressure is applied.
Base: the cross-bar below the track.
Bed; a heavy casting with smooth face, which supports the *form*
Belt; a leathern strap attached to the drum, moving the bed back and forth under the platen.
Cap; a heavy cross-bar connecting the *cheeks* or *standards*.
Carriage; the bottom of the bed resting on the *track*.
Cheeks; the uprights at each side of the platen.
Drum: the pulley on the rounce.
Frame; the *cheeks*, *head*, and *base*.
Frisket; a light frame pivoted to the tympan.
Gallows; an upright to support the tympan.
Girdle; the belt.
Head; the cap.
Hook; a substitute for the gallows.

Lever; the *bar* or *devil's tail.*

Platen; a casting with smooth under face parallel with the bed.

Press-cloth; a blanket inside the tympan to regulate impression.

Rounce; the winch which moves the bed.

Spindles; bolts parallel with the cheeks to hold the platen in parallelism with the bed.

Springs; to lift the platen.

Standards; the cheeks.

Toggle; the compound lever through which pressure is applied.

Track; the bars on which the bed slides.

Tympan; a frame covered with linen pivoted to the bed, so as to turn down over the form.

Tympan-drawer; a frame just fitting the tympan. The press-cloth comes between the tympan and drawer.

Wedge; a double inclined plane above the platen to regulate impression.

Power-presses. Nicholson obtained a patent in England, 1790, for a cylinder printing-machine which is believed to be the first on record. It was not brought into effective use, but some of the ideas were quite original, and were adopted by subsequent inventors. The main features are as follows: —

"The types, being rubbed or scraped narrower toward the foot, were to be fixed radially upon a cylinder. This cylinder, with its type, was to revolve in gear with another cylinder covered with soft leather (the impression-cylinder), and the type received its ink from another cylinder, to which the inking apparatus was applied. The paper was impressed by passing between the type and impression cylinders" — HANSARD.

König, a German, constructed a printing-machine for Mr. Walter of the London "Times," in 1814; the issue of the 28th of November of that year, being printed on König's press, was the first newspaper printed by machinery driven by steam-power. The rate was 1,100 impressions per hour; this was afterward increased to 1,800. In this machine ordinary type was used; the form was flat, and passed beneath a large cylinder which delivered the impression.

The paper was held to its cylinder by tapes; the form was reciprocated beneath the inking apparatus and the paper-cylinder alternately. To double the rate, a paper-cylinder was to be placed on each side of the inking apparatus. The ink was placed in a trough and ejected upon the upper of a series of rollers, passed downward in the series; and here first occurred the distributing-roller with end motion.

König designed to combine two single machines to form a perfecting-press, but did not succeed.

Donkin and Bacon's machine, 1813, was built for the University of Cambridge, England. Several forms were attached on the sides of a prism, and were presented consecutively to the inking-cylinder and paper-cylinder. In this machine were first used the composition inking-rollers of glue and molasses.

In 1815, Cowper obtained a patent for curved electrotype-plates to be affixed to a cylinder. The greater portion of the cylinder formed a distributing surface for the ink; the remainder was occupied by the stereotype-plate.

Applegath and Cowper's single machine went back again to the flat reciprocating bed. This machine was the first to have diagonal distributing-rollers to spread the ink smoothly by sliding on the reciprocating inking-table.

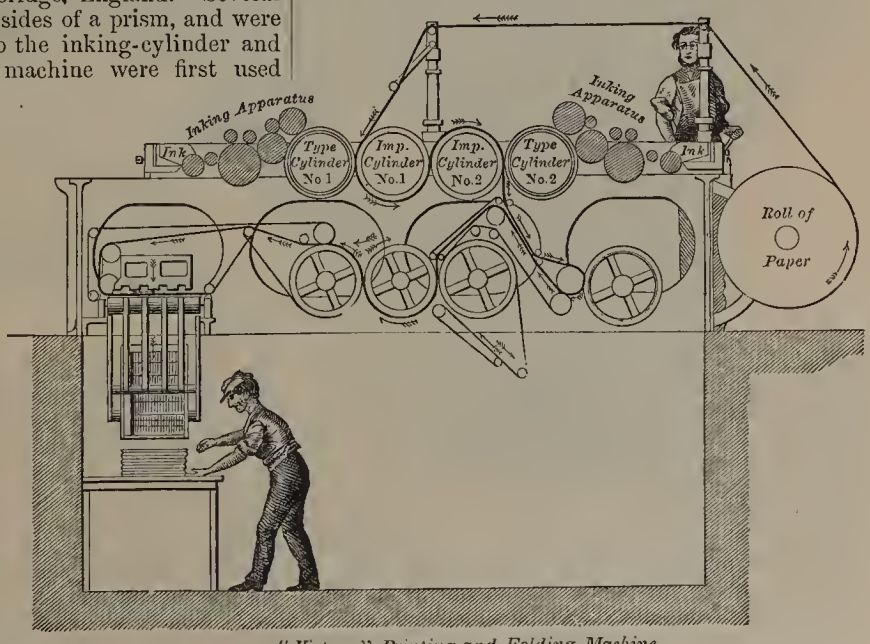
Applegath and Cowper's four-cylinder machine, 1827, superseded König's in the "Times" office, and printed at the rate of 5,000 per hour, on one side. It had four printing-cylinders, one form of type on a flat bed, and the paper-cylinders were alternately raised and depressed so that two were printed during the passage one way and the other two on the return passage. A pair of inking-rollers between the paper-cylinders obtained their ink from the table.

Applegath's machine, 1848, was long used upon the "Times." It introduced one novelty: placing the whole series of cylinders on end. On the vertical type-cylinder the type was arranged in upright columns, forming flat polygonal sides to the drum. Arranged around it were eight sets of inking apparatus, alternating with eight impression-cylinders, and the paper, fed from eight *banks*, was delivered upon as many tables. The paper fed from each feed-board was carried by tapes and rollers, and, passed on edge to the type and impression cylinders, was carried off, thrown over flatwise, and laid by boys upon the pile on the table. The number of sheets per hour worked upon this machine rose from 8,000, in 1848, to 12,000, printed on one side.

The Hoe type-revolving printing-machine is made with two to ten printing-cylinders arranged in planetary form around the periphery of the larger type-carrying cylinder. The type is secured in *turtles*, or the stereotype is bent to the curve of the cylinder. The circumference of the central cylinder has a series of binary systems, the elements of which are an inking apparatus and an impression apparatus, the paper being fed to the latter and carried away therefrom by tapes to a flyer, which delivers it on to a table. It has as many banks as feed or impression cylinders. See CYLINDER-PRESS.

There are numerous modifications of the flat-bed and type-revolving machines for more or less rapid work; perfecting, or for one side only; for fine wood-cut work, for book work, or job work; with continuously revolving cylinders, or stop cylinders, which pause while the bed returns; with inking-rollers varying in numbers with the kind of work required; and with many other variations in size for posters, hand-bills, and cards.

Fig. 3951.



"Victory" Printing and Folding Machine.

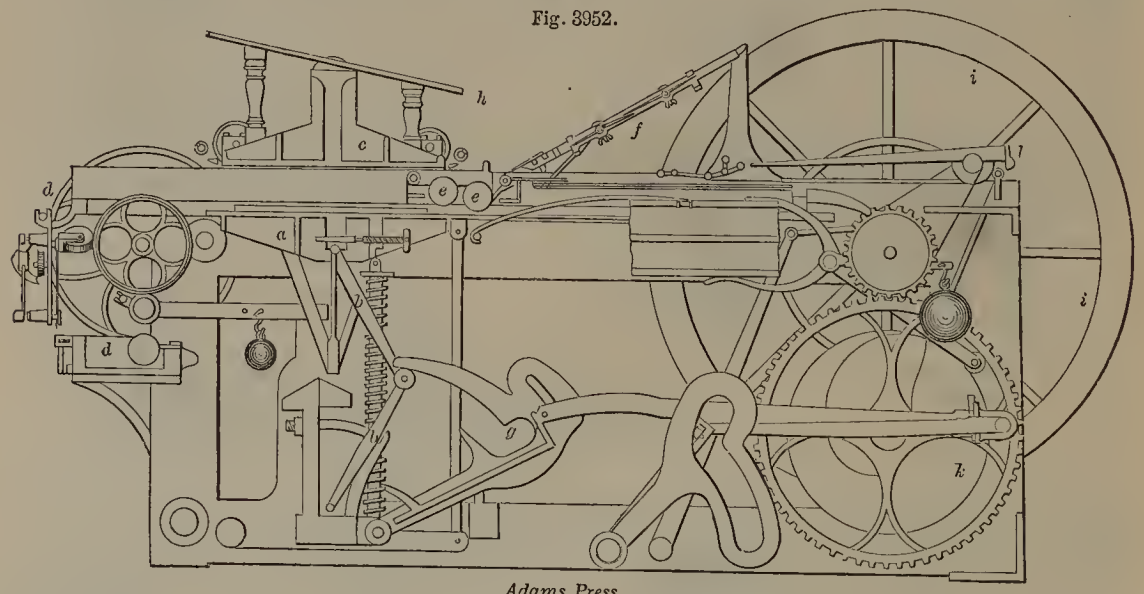
The "Victory" printing and folding machine is illustrated in the plate opposite. The roll of paper is placed on brackets at the end of the machine; the paper is led over two wetting-boxes, then, being damped, is led over two hot copper cylinders and entered between the first printing and impression cylinder; when it is printed on one side, it enters between the second pair of cylinders, which print the paper on the second side; it then travels on tapes to the cutting and folding cylinders. The *first* fold is given by a blunt knife fixed transversely across the peripheries of the wheels, and forces the paper into the gripper of a second cylinder, which carries the doubled paper half a revolution; a serrated steel knife is then forced through the intervening web of paper into a groove, thereby cutting the first perfect printed sheet from the web; a second blunt knife forces the doubled paper into the grippers of the third folding-cylinder; the newspaper thus twice folded is carried round by the grippers to a vibrating frame, entering each alternate sheet to a pair of cross folding-rollers, when it is forced by means of a steel knife, raising the middle of the paper between the tapes which traverse up each side of the delivery end of a frame, carrying each alternate sheet to the second pair of rollers, when the second cross folding-knife comes sharply down and forces the middle of the paper in between the two rollers under which the delivering apparatus works. This delivery consists of a frame which swings backward and forward like a pendulum, the papers traveling down between the tapes while it is going one way, and being thrown out as it comes back, falling like flakes on to the top of the accumulating heap on the table, where they are piled regularly one over the other. This machine is especially adapted to damp, print, cut, fold, and deliver an eight or a four page newspaper. It prints and folds 9,000 perfect copies of an eight-page paper of fifty inches square, or 18,000 copies of a four-page paper per *hour*. It also prints, folds, and pastes at the back a twenty-four-page paper, like the "Christian Union," of New York, this at the speed of 7,000 per hour. The space required for the working of this machine is eighteen feet long, ten feet wide, eight feet high to the top of the delivery frame. With the lower delivery, as shown in Fig. 3951, a pit underneath the machine is required. The plate shows the upper delivery. In working, it only requires one pressman, and one boy for taking away the papers; and as it folds the papers at the same time that they are printed, it saves the cost and expense of working separate folding-machines, which have always been used until the "Victory" combined machine for printing and folding was invented. See also PERFECTING-PRESS; WEB-PRESS.

Fig. 3951 shows the "Victory" with lower delivery.

Fig. 3952 is a longitudinal vertical section of an Adams flat-bed press. *a* is the bed of the press, which is raised by straightening the toggles *b b*; *c* is the platen; *d* is the ink-fountain and ink-distributing apparatus. The inking-rollers *e e* pass twice over the form, and are attached to the frame of tympan *f*. The segment *g* serves to straighten the toggles and cause the impression. *h* is the feed-board; *i*, the drive-pulley; and *k*, a gear-wheel with pitman-rod to *g*. *l* is the fly.

The first power-printing machine in the United States was the invention of Daniel Treadwell, of Boston, in the year 1822. Two of these machines were set up in New York City, one in the printing-house of the "American Bible Society," and another

Fig. 3952.



Adams Press.

in that of the "American Tract Society." The former was driven by a steam-engine and the latter by two mules working in the upper story, the animals having been hoisted by means of tackle. This machine was a flat-bed press, and was long a favorite; it was used by Gales and Seaton in Washington in their printing for the United States government. The platen was moved to the form, and not the form to the platen; as with the Adams, which is shown in Fig. 3952.

The Adams power-press was introduced in 1830, but has since been much improved, and still stands very high with book-printers. Its movement is based on that of the hand-press, and gives a perfectly flat impression by lifting the bed of the press and its form against a stationary platen. Sheets are fed to the press by hand, and taken away by tapes and a fly. One thousand impressions per hour is a fair speed for a large Adams press on book forms.

Single-cylinder presses have a flat bed which is geared to reciprocate at an even speed with a revolving cylinder. Sheets of paper are fed to the cylinder, which carries a prepared tympan. The inked form runs along with the sheet until it is printed, when the form is retracted and inked again.

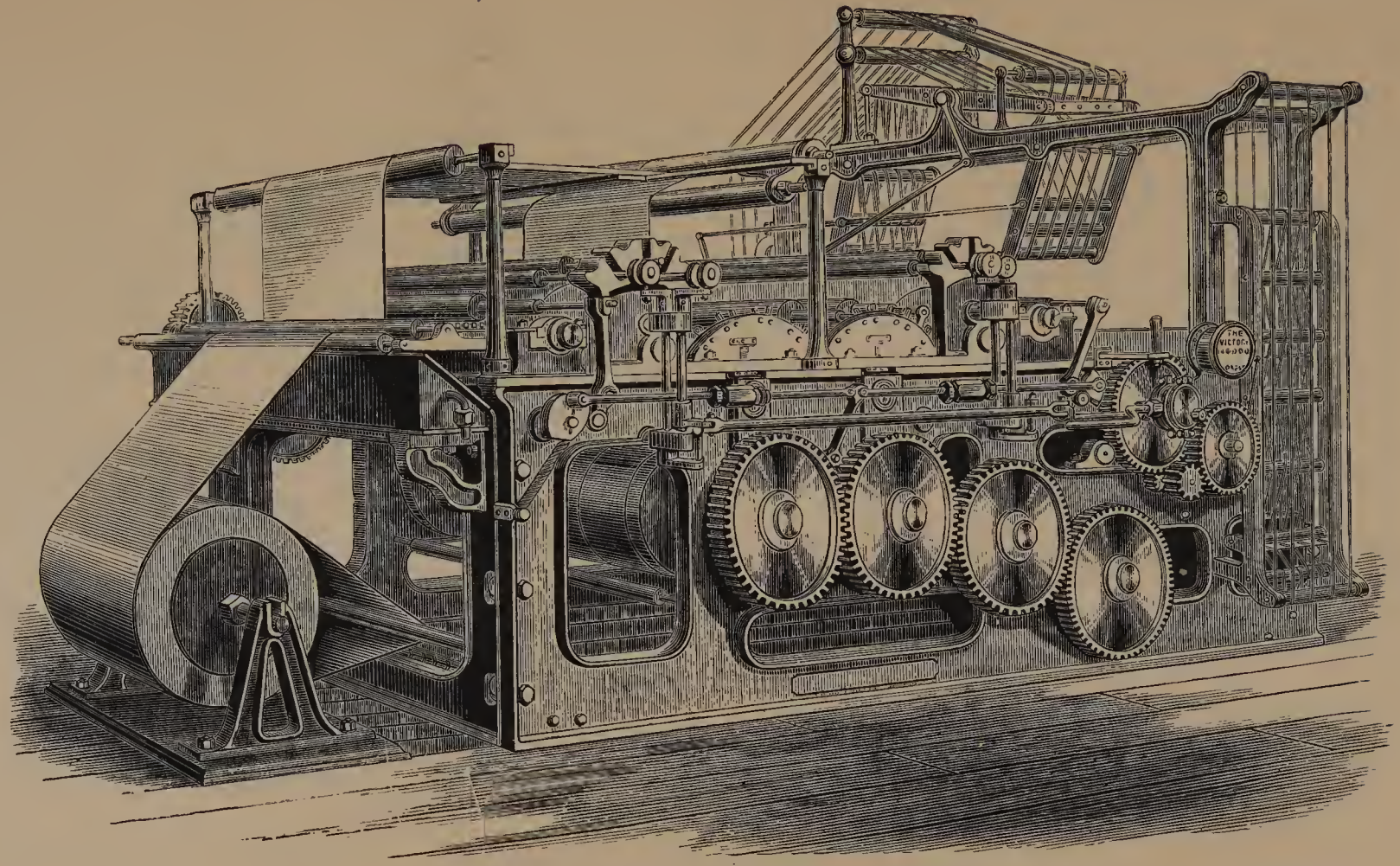
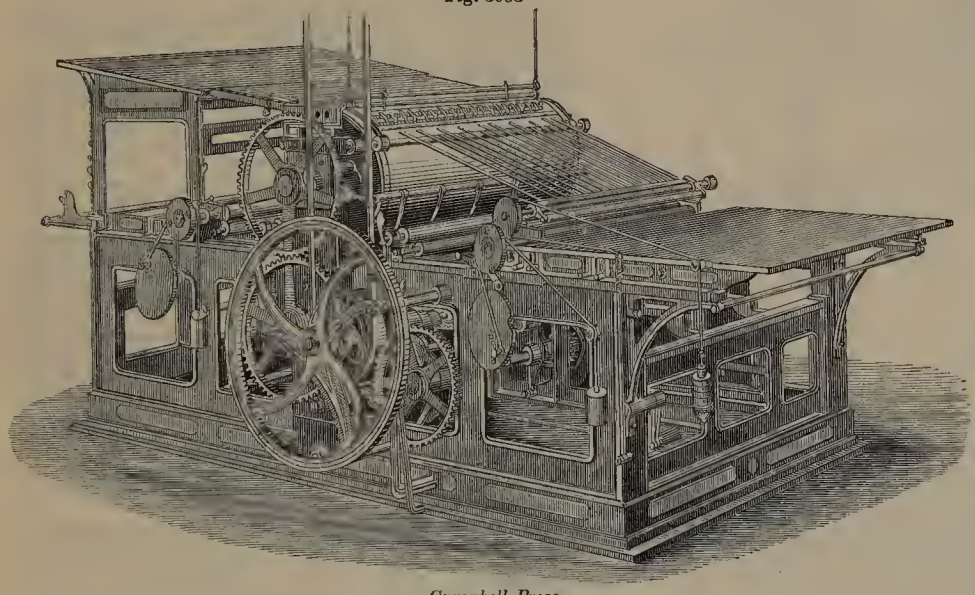


PLATE XLIII. THE VICTORY PRINTING AND FOLDING MACHINE. *See page* 1798

A segment of the cylinder is removed to allow of a backward movement of the bed, and in some machines the cylinder stops after a partial revolution. See CYLINDER-PRESS.

Fig. 3953 is a single-cylinder press of the Campbell pattern. It is controlled in its operation entirely by the sheet, so that it is impossible to print the sheet out of register. When a sheet is fed badly it is thrown out unsoiled, and it will continue to be thrown out so until it is properly fed. If pointing is necessary in fine register, the points are operated by electricity, in which case it is impossible to print out of register on it. This result is obtained through an exhaust-apparatus that operates a bolt attached to a diaphragm, which locks up the impression. The registering is operated by a small valve, through the agency of points making a circuit through the point-holes in the sheet, it being necessary that both should be through before the impression is thrown on to point the sheet. When the press fails to point, the former is hooked up and the fountains are thrown out of gear. Color is taken for each successive sheet only. Another peculiarity is a double fountain, having two sets of inking apparatus which distribute the ink on the form in two strata; these, like two wedges, overlap to form a single stratum of uniform thickness throughout. There is one inking apparatus on each side of the cylinder. As many as four-

Fig. 3953.



Campbell Press.

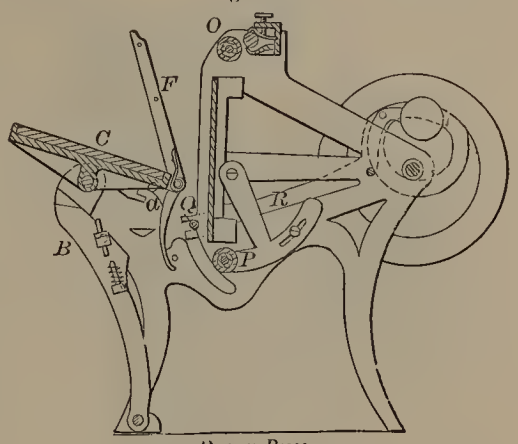
teen distributing and inking rollers may be used with this press.

A large number of small job-presses have been built by American mechanics, and are capable of doing excellent work at very high speed. Among these may be mentioned the *Gordon*, *Globe*, *Liberty*, *Universal*, *Cincinnati*, and others, adapted to print sheets to the size of foolscap or larger. Three sizes are in common use, known by the size of the sheet they will print, as $\frac{1}{8}$, $\frac{1}{4}$, and $\frac{1}{2}$ medium presses.

Fig. 3954 shows a press of this character. *C* is the platen, which pivots in the shaft *B*, and is thrown into parallelism with bed *Q*, by the curved projection *a*. The rolls are carried by arms *R*, and receive ink from the distributing cylinders *O*, *P*, above and below the type form.

In the Gordon press (Fig. 3955, upper one), the form is secured in a chase which is clamped to the bed *b* of the press. This bed rocks on a pivot at *c*, and

Fig. 3954.



Denny Press.

comes into parallelism with the platen *p* when the impression is about to be given. The platen rocks on the main shaft *d*, which is propelled by pitman and intermediate gearing from the treadle *i*. The arm *m s* is the roller-carrier, which swings on a pivot *r*, and carries the rollers *n n* alternately over the form and the revolving disk *t*, which distributes the ink; *g* is a counterweight to balance the swinging bed and attachments, and operates the movable fingers by a spring bar *a*. A feed-board *v* rests on top of the frame of the press. The platen is moved by set-screws, and is covered by the usual blanket.

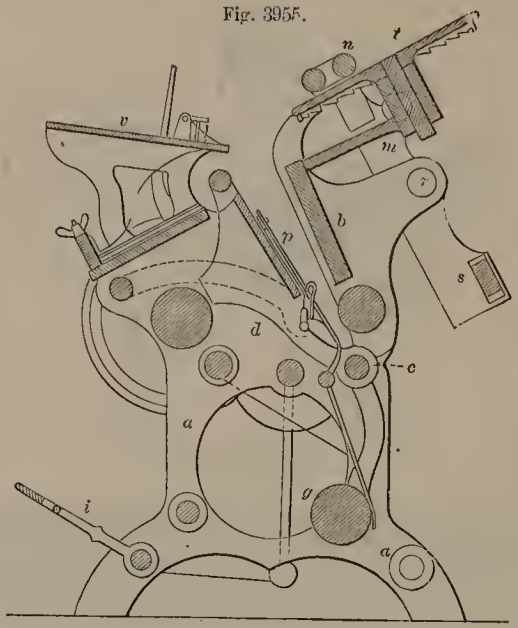
Gordon's press (Fig. 3955, lower one), patented March 3, 1874, has a rocking platen and bed, bound together by a compound toggle-lever, which holds them in locked position during the impression, as seen in the figure. By straightening the toggle-lever, the bed and platen are rocked back out of parallelism, the form on bed *a* is rolled, and a fresh sheet fed to platen *b*.

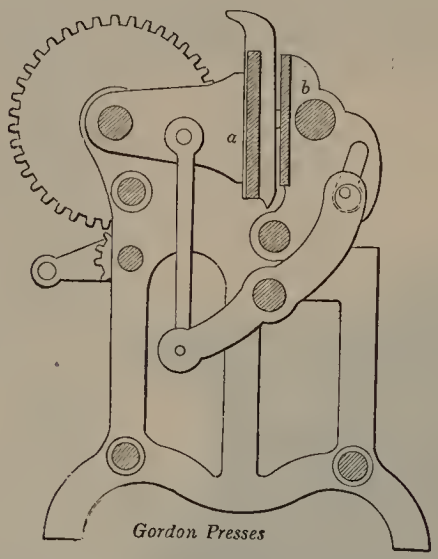
Bryson's inking apparatus for printing-presses, patented June 30, 1874, relates to a means for inking the types from one fountain in opposite directions, so that there is an equalization, one set of form-rollers commencing when charged at the front edge of the form and inking toward the back, and the other commencing at the back and inking toward the front of the form, so as to secure equality in the distribution of the ink, with but few rollers.

Leboyer's press uses a sheet of porous paper introduced between the type and the card, as a substitute for fluid ink and the roller.

Hydraulic presses have been adapted to the printing of bank-notes and steel and copperplate engravings, but their operation is necessarily slow. See

Fig. 3955.





Gordon Presses

COPPERPLATE-PRESS; LITHOGRAPHIC PRESS; TICKET-PRINTING PRESS, etc. See also PERFECTING-PRESS; WEB-PRESS; CYLINDER-PRESS.

A valuable compendium of patents on printing-presses may be found in Ringwalt's "Encyclopædia of Printing," pp. 236–248.

2. (*Plate-printing.*) See COPPERPLATE PRINTING-PRESS.

Print'ing-tel'e-graph. An electro-magnetic telegraph which automatically records transmitted messages. The term is, however, generally applied only to those which record in the common alphabet, so that the message may be understood by an ordinary reader.

The first of this kind with which we are acquainted was invented in 1837 by the late Alfred Vail, well known for his connection with the early progress of the Morse instrument in this country.

The operation of this depended on the synchronous vibration of two pendulums, one at each station, by which the corresponding letters on the two type-wheels at the transmitting and receiving stations were simultaneously brought into vertical position, that at the receiving station being thrust upward so as to print on a slip of paper when the appropriate letter at the transmitting station came upward and completed the circuit. As only one letter was advanced at each beat of the pendulum, and it would of course frequently happen that nearly a complete revolution of each type-wheel would be required in order to bring into proper position the next letter to be transmitted, the rate of transmission was exceedingly slow. Accordingly, the apparatus, though ingenious, never came into practical use.

In 1840, Mr. Alexander Bain, the ingenious inventor of the electro-chemical telegraph known by his name, invented a printing-telegraph in which type-wheels at each station were caused to rotate at exactly equal speeds by means of clock-work mechanism driven by springs.

The circuit was completed by means of a pin, which could be inserted in any one of a number of holes arranged around a dial-plate and corresponding to the series of Arabic numerals. While the circuit was complete, the operative mechanism was prevented from working by means of pallets on an upright cranked shaft engaging with a pivoted bar controlled by a governor. The circuit was broken by removing the pin from the hole in which it previously was and inserting it in that corresponding to the figure next to be transmitted; this, by releasing a pivoted electro-magnet having a detent arm, allowed the spring actuating the mechanism to act, causing a governor to operate, releasing the detent bar from the pallets and permitting the crank-shaft to rotate until the appropriate figure on the type-wheel could be acted on by a lever connected therewith, which took place when the pin inserted in the dial came in contact with a fixed hand thereon, when the circuit was again completed and the mechanism stopped; at this moment the figure was pushed into contact with a roll of paper, to which a movement at once rotary and upward was imparted by the clock-work. The message was thus imprinted upon the roll in a spiral line.

House's printing-telegraph, patented in 1848, to date from April 18, 1846, has been extensively used in the United States.

It consists of a composing-machine and a printing-machine at each station, the former of which is included in, and the latter distinct from, the circuit.

The circuit commences in the battery of one station, passes along the line wire through the coil of an axial magnet to an insulated iron frame of the composing-machine of the next station, thence to a circuit-wheel revolving in this frame, enters a spring pressing on the edge of the circuit-wheel, and has a connection with the return wire, along which the electricity passes through another battery back to the station whence it came.

The composing-machine is arranged within a case on top of which the printing-apparatus is placed. Both are driven by a hand-crank carrying a fly-wheel and a pulley over which passes a band that turns the operative mechanism pertaining to each. An insulated iron frame immediately below the keys has within it a revolving shaft rotated by a hand and pulley on one of its extremities; the shaft is partially inclosed within an iron cylinder, with which it is connected by a friction device, so that they may revolve together, or the shaft may have independent rotation. On the opposite end of the cylinder is a brass wheel, called the circuit or break wheel, 4 or 5 inches in diameter, and having 14 teeth and the same number of interspaces on its periphery.

The shaft and cylinder form a part of the circuit, one point of connection being where the shaft rests on the frame and the other with a spring which, when the apparatus is rotated, alternately strikes a tooth and drops into a space, thus closing and breaking the circuit.

The cylinder has two lines of teeth, 14 in each, spirally arranged along its opposite sides, which correspond with stops on the under surfaces of the keys, so that when one of the latter is pressed down the motion of the cylinder is arrested. Its continuous rotation causes the circuit to be rapidly broken or closed; but when one of the keys is depressed the cylinder is held in position, maintaining the circuit either open or closed, as it happened to be at the moment, and so continues until released from contact with the key or until another key is manipulated.

The electrical pulsations are transmitted to the printing-machine at the other station through a peculiarly constructed axial magnet, having a valve at its upper end, to which condensed air is admitted from a chamber into which it is compressed by an air-pump operated by the fly-wheel. The stem of the valve has a series of bell-shaped flanges, which make and unmake connection with a series of corresponding flanges within the magnet during the pulsation of the current, causing the air admitted to the valve to operate a piston arranged at right angles thereto, and which is connected with the lever of an escapement whose pallets engage pins on the upper surface of the printing-wheel. Each vibration of the valve thus advances the printing-wheel one letter. When a stop is made while the machine is in operation, when the circuit remains open or closed for more than one tenth of a second, an eccentric draws a shaft on which the paper strip is carried forward up against the type-wheel, which, by means of an interposed endless coloring band, impresses the letter then presented upon the paper. See Shaffner's "Telegraph Manual."

Hughes's telegraph, 1856, requires but a single

current for each letter; the reception and transmission of messages simultaneously over the same wire and printing from the type-wheel while in motion are provided for by appropriate devices.

The most important of these are: 1. A *chariot* which revolves with a vertical shaft having the same velocity as the type-wheel, over tho surface of a disk pierced with a nuuber of perforations equal to the letters on the type-wheel, iuto which project the ends of a number of pins that are raised by the uovement of keys arranged like those of a piauo-forte. When the chariot passes over a pin thus raised, a conuection is established with the line-wire and a current is transuitted to the next statiou. While passing over an interspace the current is diverted through the disk to the earth.

2. On its way to the line-wire the current traverses the coils of an electro-uagnet, beueath which is a perumaneut steel horse-shoe magnet having its polcs in contact with the soft iron cores of the electro-magnet. The magnetism induced in the coils when no curreut is passing causes them to attract and hold down an armaturc against the force of a spring. When connection is made, as above stated, with the local battery, the current, which is opposed to that of the steel magnet, weakens the effect induced by the latter in the coil sufficiently to permit the spring to withdraw the armature, through which an impulse is transmitted and the circuit again instantaneously broken.

The above arrangement renders the apparatus extremely sensitive.

When the armature rises, the shaft of the printing-wheel, which is in two parts, locking with each other, turns the wheel at the same moment that a cam movement is caused to press a strip upward against the type-wheel, which imprints the letters.

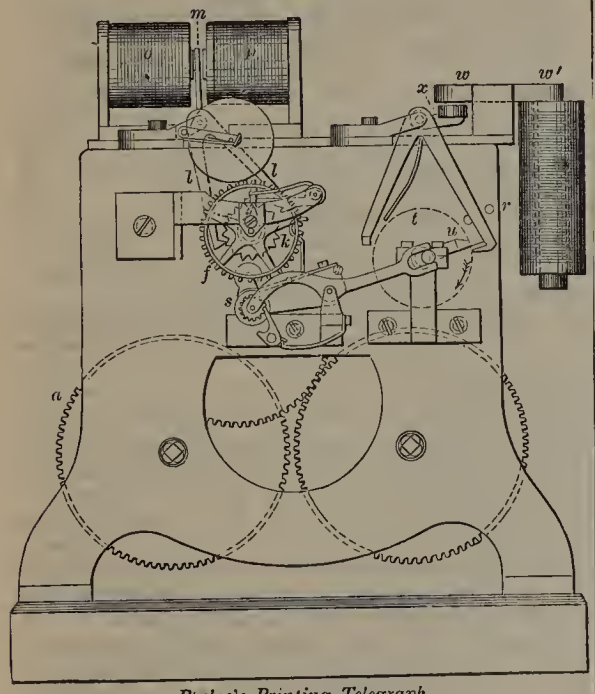
The chariot and type-shaft are readily adjusted to correspondence, if required, previous to the transmission of a message, and any slight inequalities in their motion are automatically adjusted by the machine itself.

Printing-telegraphs may be divided into two classes: those on the step-by-step principle, and those in which the type-wheel is continuously rotated by an independent motor, the circuit of the printing-hammer being closed when the letter is opposite to the printing-pad. The House, Hughes, and Phelps machines belong to the latter class, and those of Vail, Bain, and others to be cited, to the former. The most recent types of step-by-step printing-telegraphs are: —

a. Those having clock-work mechanism controlled by an electro-magnetic escapement.

b. The clock-work is dispensed with and a ratchet-wheel on the type-wheel shaft is actuated by a pawl attached to an armature.

Fig. 3956.



Phelps's Printing-Telegraph.

c. The type-wheel is mounted directly upon the shaft of an electric motor, the armature-wheel of which revolves between the poles of two electro-magnets.

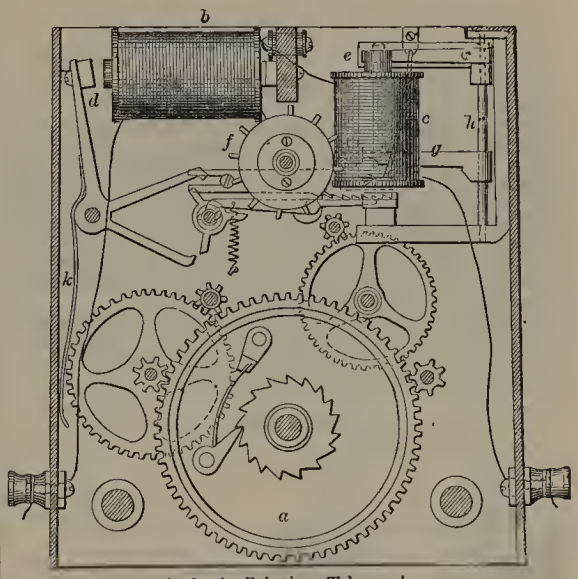
a. Phelps's printing-telegraph, November 4, 1873 (Fig. 3956).

The type-wheel *f*, driven by clock-work mechanism from the spring-barrel, is placed on a shaft concentric with the ratchet *k*, which is coutrolled by pallets of the escapement *l l* attached to the permanently magnetized armature *m* vibrated by alternating currents through the electro-magnets *o p*. The electro-magnet *r*, controlling the printing escapement, is in the same circuit, its core having an exteusion *w*, and, being surrounded by a non-magnetic material, it is not operated by the rapidly changing currents passing through *o p*, which work the type-wheel escapement; but when the key connected with any particular letter is struck, the circuit is closed, sufficient magnetism accumulates in the core *w'* to attract the armature *x*, releasing the arm *u* carrying the paper-roller *s*, and allowing a crank-pin on the shaft of the wheel *t*, turned by a train of mechanism from the spring-barrel *a*, to depress that arm of the lever and throw the feed-roller up against the type.

Anders's printing-telegraph (Fig. 3957).

The type-wheel and printing mechanism are driven by a spring acting on the shaft of the wheel *a*. As currents alter-

Fig. 3957.



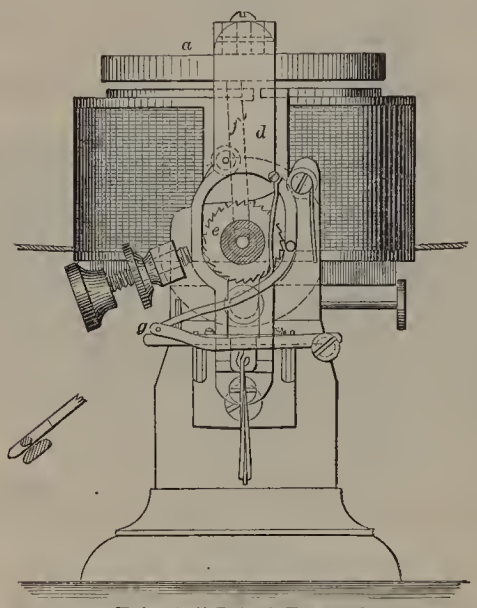
Anders's Printing-Telegraph.

nating in direction are passed through the electro-magnet *b* and polarized magnet *c*, the armature *d* of the former is attracted and held to its poles, while the armature *e* of the polarized magnet *c* is caused to vibrate laterally between the poles of this magnet, releasing one by one the teeth of the scape-wheel *f* on the type-wheel shaft from contact with a pallet on the arm *g* of the rock-shaft *h*, which is operated by the vibrations of the armature. An intermittent motion is thus imparted to the type-wheel, advancing it one letter at each electric pulsation; and when, by touching the proper key, these are suspended, the spring *k* draws back the armature *d*, the press mechanism is released, and an impression is taken, the type-wheel being now at rest.

b. Edison's printing-telegraph (Fig. 3958).

The printing and type wheels are actuated directly by the armature of the electro-magnet. The armature *a* is secured to a lever which swings on screw-centers and is connected to a bar *d*, carrying a pawl which engages a ratchet-wheel *e* fixed on the type-wheel shaft. The vibrations of the armature alternately raise and depress the lever, causing the pawl on the bar to advance the type-wheel one letter at each vibration. During the pulsations the motion of the armature is limited by a stop on a vibrating polarized bar, so that no impression is made; but when the current is reversed, the bar is attracted, releasing the stop, permitting a spring to act on the armature, which is carried up to the full limit of its motion, bringing a pad, connected with the lower part of the bar, against the paper strip which is pressed against the type-wheel. The full downward movement of the connected lever and bar actuates a dog at *g*, which advances the paper the required distance for each impression.

Fig. 3958.



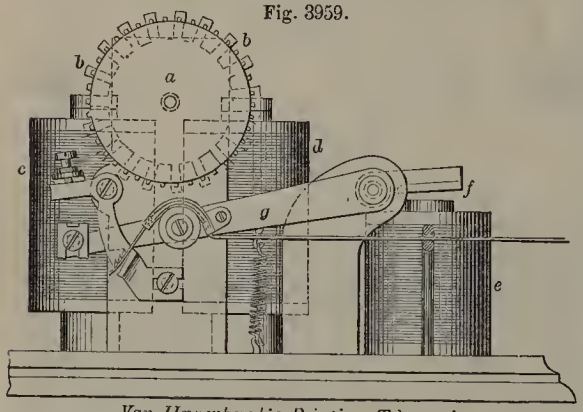
Edison's "Baby" Telegraph.

c. Van Hœvenbergh's printing-telegraph.

The type-wheel *a* is upon the same shaft with a wheel *b*, having radial armatures and revolved between the poles of two electro-magnets *c d*. *e* is one of two printing-magnets. A rotating circuit-changer opens and closes the circuit through each of these magnets alternately, the rapidity of the changes being proportioned to the speed with which the circuit-changer is revolved. The armatures of the wheel *b* are so adjusted that when the wheel is stopped by the cessation of a current, the armature next to be attracted shall be near its attracting core, so as to be operative in renewing the revolution.

To effect the printing, the current of an auxiliary battery is, by depressing a key, caused to pass through one of the magnets *e*, which, attracting the armature *f*, lifts the printing-pad on the lever *g* into contact with the type-wheel.

Fig. 3959.



Van Hœvenbergh's Printing-Telegraph.

Fig. 3960 is George L Anders's printing-telegraph stand. It has a key-board and a visible dial, being actuated by the ordinary step-by-step movement. When transmitting, the current is derived from a magneto-electric machine driven by a treadle.

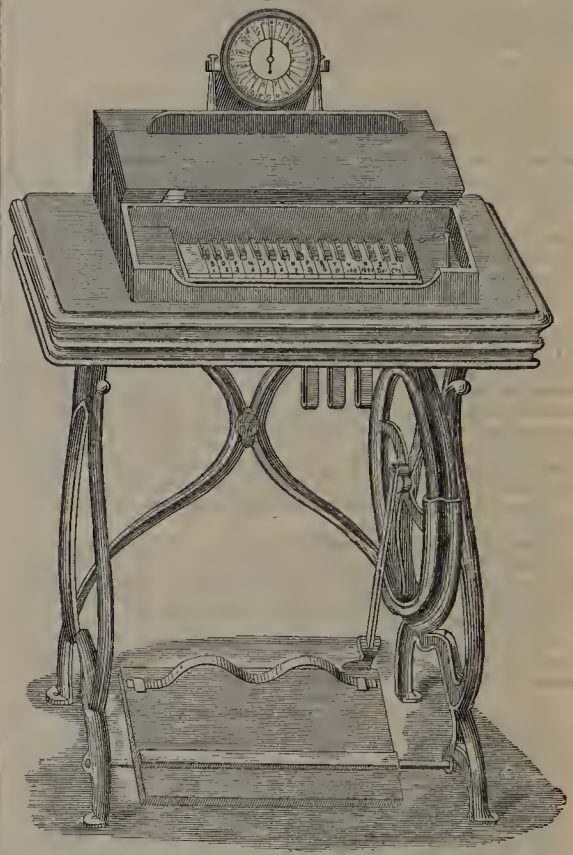
Brett's printing-telegraph, invented about 1845, is thus described in an English work: —

"A small key-board has a row of ivory keys, marked with the letters of the alphabet and other characters. Connection is made by the wire to a machine at the other extremity of the line. This machine has a type-wheel having on its circumference letters and characters corresponding to those on the key-board. A given key on the key-board at the transmitting end being depressed, a clock-work is released, causing a barrel beneath the key-board to revolve until one pin in the spiral row on its surface catches against the lower end of the key depressed.

"A counterpart movement takes place in the printing-machine at the receiving end, the depression completing the electric circuit and releasing an escapement in the printing-machine at the receiving end, causing a type-wheel to revolve. This is inked by a little flannel roller, which is kept in gentle contact with it. Above the type-wheel a slip of paper is moved along by rollers when the machine is in action, and at the proper moment a hammer presses down the paper on the type that is uppermost, and an impression is delivered thereon."

Such is a mere sketch of the devices employed in the Brett printing-telegraph, which was used in connection with the first submarine cable between England and France.

Fig. 3960.



Anders's Printing-Telegraph Stand.

Print'ing-type. See TYPE.

Print'ing-wheel. One used in paging or numbering machines or in ticket-printing machines. It has letters or figures on its periphery. In the one illustrated, the sections containing salient letters are hinged together and the chain lapped around a core.

Fig. 3961.

Printing-Wheel.

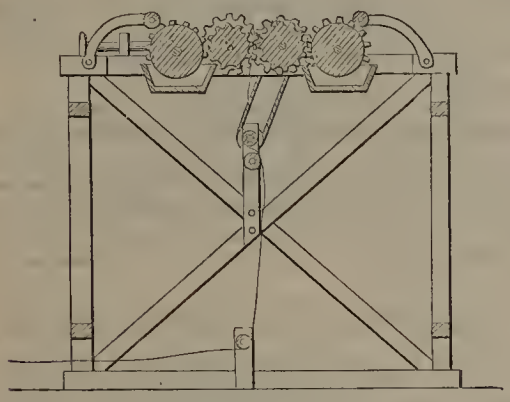
Print'ing Yarn. A machine for printing yarn for party-colored work. In the example, the yarn to be printed is run between two fluted rollers, one of which is adjustable by means of set-screws. These rollers are supplied with color by means of other rollers supplied from troughs properly arranged.

Pris-cil'las. (*Glass-blowing.*) A jaw-tool resembling a pinchers, used for pinching in the neck of a bottle, or of giving it some peculiar shape while it is revolved on the end of the *pontil* which rolls upon the arms of the glass-blower's chair. *Pucellas.*

Prise-bolts. (*Ordnance.*) The projecting bolts at the rear of a mortar-bed or garrison gun-carriage under which the handspikes are inserted for training and maneuvering the piece. They are formed by the prolongation of the assembling bolts.

Prism. The prism, geometrically speaking, is a solid having similar and parallel bases, its sides forming similar parallelograms. The bases may be of any

Fig. 3962.



Yarn-Printing Machine.

polygonal form, and from them the prism derives its specific name, as triangular, square, hexagonal, etc. The triangular form is employed in optics, and it is usual to call any transparent medium so arranged that the surfaces which receive and transmit light form an angle with each other, a prism.

The fact that a variety of colors are produced by the passage of sunbeams through a piece of glass thus shaped had undoubtedly been noticed before the time of Sir Isaac Newton, but he was first to discover the unequal refraction which the different colored rays composing the solar spectrum undergo in passing through the prism ; to show that it might be separated into seven apparently distinct colors in the order of their refrangibility, commencing, when the prism is placed with an edge downward, with red, to which succeed orange, yellow, green, blue, indigo, and violet, the latter being uppermost ; to measure the breadth in the spectrum of each of these colors, and to demonstrate their connection with the phenomenon of the rainbow.

His original experiments may be repeated by any one by means of a triangular prism; an ordinary chandelier-drop will answer, placed near a slit in the window-shutter of a darkened room, so that the rays passing through the slit may fall upon one of its sides at an angle. The decomposed beam may be received on a screen or an opposite wall; the adjustment necessary to obtain the best-defined spectrum is soon determined.

Subsequent researches have proved that there are really but three primary colors, red, yellow, and blue, which combine to produce the impression of whiteness, and that the others embraced in the Newtonian spectrum are really caused by the intermingling of rays which separately would produce the effect of red, yellow, and blue. It has also been found that there are invisible rays, less refrangible than the red, which have a greater heating power than any of the visible rays, and that there are others beyond the violet which produce a greater chemical effect than do the visible rays.

The length of the spectrum formed by similar prisms of various substances is found to vary considerably, or, in other words, some have a greater dispersive power than others. Upon this fact the construction of the achromatic lens is based. See Achromatic Lens.

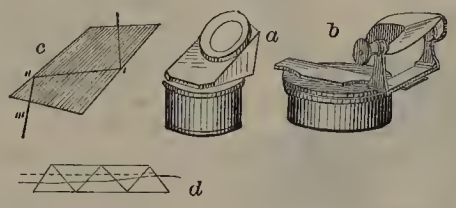
This dispersion varies in different kinds of glass, and is greater in some liquids, notably bisulphide of carbon, than in any species of glass ; for this reason it has sometimes been employed, inclosed in glass, for prisms and lenses.

Prisms are employed as eye-pieces for some kinds of instruments, as the camera-lucida and the azimuth-compass, and are also used in connection with the microscope, serving to erect an inverted image (Nachet's, *a*, Fig. 3963), or as an illuminator and condenser (Amici's). The former is interposed between the two lenses forming the eye-piece ; the inverted object formed by the field-glass passing through the lower eye-lens is transmitted to the upper surface of the prism, and after undergoing a series of reflections within the prism, emerges erect from its upper surface and is viewed through the upper lens.

Amici's (*b*) is placed near the object-end of the instrument, and serves to reflect and condense the light on an object upon the stage when it cannot be illuminated by the mirror ; it is movable, so that the light may be thrown on the object at different angles, that it may be more perfectly examined.

Wenham's (*c*) is designed to divide the cone of rays proceeding from the objective, so that the magnified image may be viewed by both eyes. The prism is so placed in the tube that the pencil striking its lower surface undergoes little or no refraction. On reaching ′, one half is transmitted directly to one eye, while the other half, after undergoing two reflections at ″ and ‴, is transmitted to the other eye ; by this arrangement

Fig. 3963.



Prisms.

a, Nachet's erecting-prism.
b, Amici's illuminating-prism.
c, Wenham's binocular prism.
d, Arrangement of prisms in spectroscope eye-piece.

the rays passing through the left half of the objective are transmitted to the right eye, and those from the right half to the left eye.

By placing two prisms in reverse positions, the light decomposed by one is recomposed by the other, so as to exhibit a white beam. When two or more are so arranged that the second receives the beam transmitted from the first and deflects it in the same direction, though the colors undergo no farther decomposition, the length of the spectrum, *i. e.* the dispersion, is increased, the space occupied by each color being proportionately lengthened. An arrangement *d* of this kind is called a train of prisms, and is used in the spectroscope.

In Sorby and Browning's spectroscopic eye-piece, which may be applied to any microscope, a train of five prisms (*d*), the inner, middle, and outer ones of which are of crown, and the two interposed ones of flint glass, are placed in a tube above the achromatic eye-glass ; the rays entering the train, which have been separated by the greater dispersive power of the flint glass, emerge from the upper prism in a direction parallel to their original incidence. See Spectroscope.

It is customary, for convenience' sake, in modern practice to place the prism or prisms, when more than one is employed, in a vertical position, and to provide devices for intercepting the light so that a square spectrum may be formed.

Besides being used for resolving white light into its elementary colors, the prism is, as well as the mirror, employed for polarizing light.

Through its instrumentality, by means of the spectroscope and the polariscope, we are enabled alike to determine the constitution of the fixed stars and to ascertain the chemical components of the minutest particles of organic matter, opening a field of scientific inquiry the boundaries of which cannot as yet be even imagined.

Nicol's prism is used as an adjunct to the microscope in examining the properties of polarized light. Its action depends on the doubly-refracting property of the material (Icelaud spar) of which it is composed.

On viewing a small object, such as a black dot on a sheet of paper through a piece of Iceland spar or of selenite, two images will be seen ; on turning the spar around, one of these images will appear to revolve about the other. The fixed image is called the ordinary, and the other the extraordinary image ; the line joining them is always in the direction of the shorter diagonal of the crystal when its edges are of equal length and the angle between the ordiuary and extraordinary ray is 6° 12′.

The action of this spar is to refract the light into two divergent pencils, forming the *ordinary* and *extraordinary* rays, the differences in the angle being 6° 12′ The crystal being bisected by a plane passing through its obtuse angles, and forming an angle with the principal axes of the crystal of 22°, the two surfaces being finely polished and brought together, one of the rays suffers total refraction and passes out at the side, while the other, being within the angle of refraction, passes on through the other section of the crystal. By this means one of the rays is eliminated, leaving the ordinary remainder ray a beam polarized in a single plane ; the other, the eliminated ray, being polarized in the other plane, but removed The object is to obtain a single polarized ray.

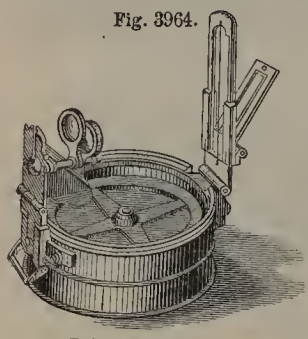
It results that a ray polarized in this direction is alone capable of passing through the prism. This enables the Nicol prism to be used as an *analyzer*

It is usual to cement the two sections with Canada balsam, the angle of refraction of which being less than that of the Icelaud spar, does not interfere with elimination of the extraor-

dinary ray. It would not be safe to say that the action is due to the Canada balsam, for the action would take place if the prism sections were merely laid together, but it would not do to cement with a material having the same index of refraction as the spar, as in this latter case the effect would be to re-make a solid crystal.

Pris-mat'ic Com'pass. An instrument for measuring horizontal angles by means of the magnetic meridian. It is principally employed in reconnoissance or in sketching the general features of a country. It resembles a CIRCUMFERENTOR (which see), but has a floating card attached to the needle graduated to 15′ of a degree. The graduations commence at the N. point, and are numbered around the circle up to 360°. A sight-vane is fixed perpendicularly, with a fine wire stretched across it, opposite to which is a prism. On applying the eye to the prism, and bisecting any object with the wire in the sight-vane, the division on the card coinciding with the thread and reflected to the eye of the observer will show the angle formed by the object with the meridian.

Fig. 3964.



Prismatic Compass.

Prism-mi-crom'e-ter. An instrument invented by the Abbé Rochon, in which the principle of double refraction is applied to micrometrical measurement. See DOUBLE-REFRACTION MICROMETER.

Prism-sphe-rom'e-ter. An instrument invented by Dr. Meyerstein of Göttingen, for ascertaining the curvature of a sphere or the deviation of the surface of any object from a plane. See Poggendorf Ann., Vol. 126, p. 589.

Pritch. An eel-spear with several prongs.

Pritch'el. (*Forging.*) The punch employed by horse-shoers for punching out or enlarging the nail-holes in a horseshoe. Also being temporarily inserted into a nail-hole in the shoe, it forms a means of handling the latter.

Pri'va-teer'. (*Vessel.*) A vessel belonging to private parties sailing with a license (letter of marque) from one belligerent party to prey upon the enemy's ships. The practice originated at the end of the sixteenth century in the war between Spain and the revolted Netherlands. Privateering is a sort of authorized piracy. Of late it has been difficult to ascertain the distinction between the two.

Priv'y. In almost all cities of the world, until a comparatively recent date, all kinds of filth were thrown into the public streets. This was forbidden in Paris by an ordinance in 1395. It was practiced till 1750 in Edinburgh. Three centuries since the royal residences of Spain were destitute of privies, while the circumnavigators found them among the Maories of New Zealand, the antipodes.

Laws ordering that every house in Paris should be furnished with a privy were passed in 1513, 1533, 1697, and 1700. A non-compliance was rendered penal. In other cities of France the same regulations were made.

Prize-bolt. (*Ordnance.*) A bolt projecting from a mortar-bed, under which a handspike is inserted in maneuvering. A *running-up bolt* or *traversing-bolt.*

Proa. (*Vessel.*) *a.* A narrow canoe, thirty feet long and three feet wide, used by the natives of the Ladrone Islands. The stem and stern are similar, the boat sailing either way. The lee side is flat, so that the canoe resembles half of a vessel divided vertically in the line of the keel. Extending to leeward is an outrigger, consisting of a frame at the end of which is a floating canoe-shaped timber, which prevents the crank and narrow canoe from upsetting.

b. A Malayan boat propelled by sails and oars.

Pro'bang. 1. (*Veterinary.*) An instrument for removing a root, apple, or other object which has lodged in the esophagus. When the piece so presses upon the trachea as to obstruct breathing, the case is critical, and the probang is used to force it down into the stomach or impale it, and thus afford means for extracting it.

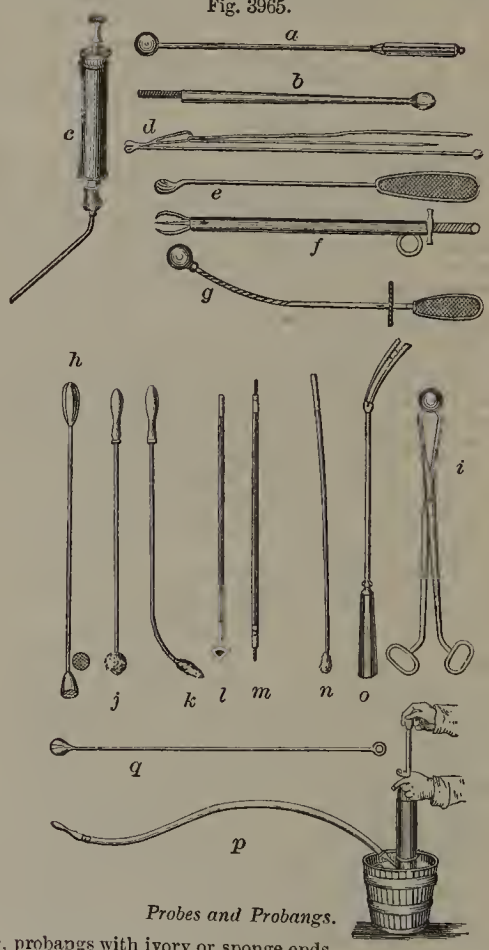
A tube of leather, even a black-snake cart-whip, may answer. Probangs are made hollow with stilettos, and have an enlarged head, so as not to pass the object. They are also used on hoven cattle to facilitate the escape of gas resulting from the fermentation of the food, or to relieve the stomach of a part of the food. In such a case it is a kind of trocar.

An enema apparatus (*p*, Fig. 3965), for injecting a diluent and withdrawing the fluid contents of the paunch, is the preferable instrument in distension by gas.

2. (*Surgical.*) A slender whalebone rod with a piece of sponge on one end, for pushing down into the stomach bodies which may have lodged in the esophagus. Sometimes the other end is provided with a silver basket on a hinge, by which bodies so lodged may be drawn out.

The sponge, acting as a *porte-mèche*, may be saturated with caustic or medicaments, which may thus be applied to the part affected.

Fig. 3965.



Probes and Probangs.

j k, probangs with ivory or sponge ends.
l m n, jointed probangs for the pocket.

o is Buck's sponge-holder, with jaws.
q is a *porte-mèche* to carry lint, a sponge, or other tent into a wound.

Probe. A surgical instrument, usually made of silver wire, having a rounded end, and introduced into wounds in exploring for balls, etc.

There are also probes to explore the uterine cavity, the *ducta lachrymalis*, etc. According to their use their nomenclature varies, as *bullet*, *uterine*, or *eye* probe. Some are provided with a groove running to their points, for the purpose of directing knives in making incisions, and are then called *director-probes*.

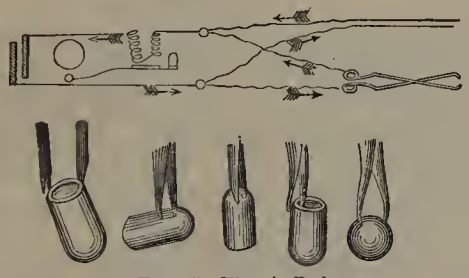
d is Tieman's probe, with eye for introducing lint into a wound.
e is a bullet-scoop.
f is Moses's bullet-extractor, with three prehensile claws.
g is Tieman's flexible seeking-probe.
h is a bur-head bullet-probe, which will receive a mark from lead in its path.
i is a bullet-forceps.

The porcelain probe for the discovery and removal of leaden balls lodged in the body was devised by Nélaton It has at its extremity a small *rugous* or wrinkled porcelain ball, which becomes blackened in contact with a leaden bullet.

Probes of iron were found in Pompeii, in the Via Consularis, in a dwelling, the supposed former residence of a surgeon. Spatulas, cauting-irons, forceps, needles, catheters, and lancets in iron and copper or bronze, were also found there by Dr. Savenko of St. Petersburg, 1819.

The electrical probe of M. Trouvé consists of two pointed

Fig. 3966.



Trouvé's Electric Probe.

steel wires projecting about four inches from an ivory handle. They are surrounded near their points by a tube of vulcanite inclosed in a slotted tube of German silver, and may be moved slightly forward so as to project beyond this by means of a button to which they are connected, sliding in the slot. The other ends of the wire are connected with the terminals of a galvanic battery, forming an open circuit. The battery is formed of a zinc and carbon element, inclosed in a case of hardened india-rubber hermetically sealed, the exciting liquid being bisulphide of mercury. For use, the probe is pushed into the wound until a resistance is encountered which in the judgment of the operator may be the bullet. The points are then protruded and the instrument turned about, if necessary, until both points touch the object, when, if it be the bullet sought, the circuit is completed by metallic contact, actuating the armature of an electro-magnet and causing it to ring a bell.

A pair of forceps for extracting the ball are similarly connected to the terminals of the battery. The figure shows the probe, terminals, electro-magnet, bell, positive and negative plates of the battery, forceps The lower figure illustrates the action of the points; when both points touch the ball the circuit is closed.

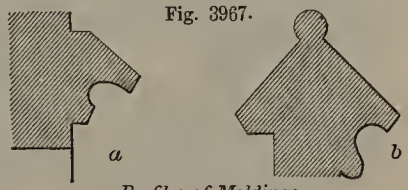
Probe-syr'inge. *c*, Fig. 3965, represents a syringe, the nozzle of which is no larger than an eye-probe. Used to throw injections into the nasal duct.

Pro-cel'las. (*Glass-making.*) A glass-maker's tool. See PUCELLAS.

Pro'che-am'e-ter. An instrument for registering the revolutions of a carriage-wheel. An ODOMETER (which see).

Pro'file. 1. (*Joinery.*) The outline of a series of moldings, or of any other parts, as shown by a section through them.

Fig. 3967.



Profiles of Moldings.
a, Lintel. *b*, Wall coping.

2. (*Engineering.*) A vertical section through a work or section of country to show the elevations and depressions.

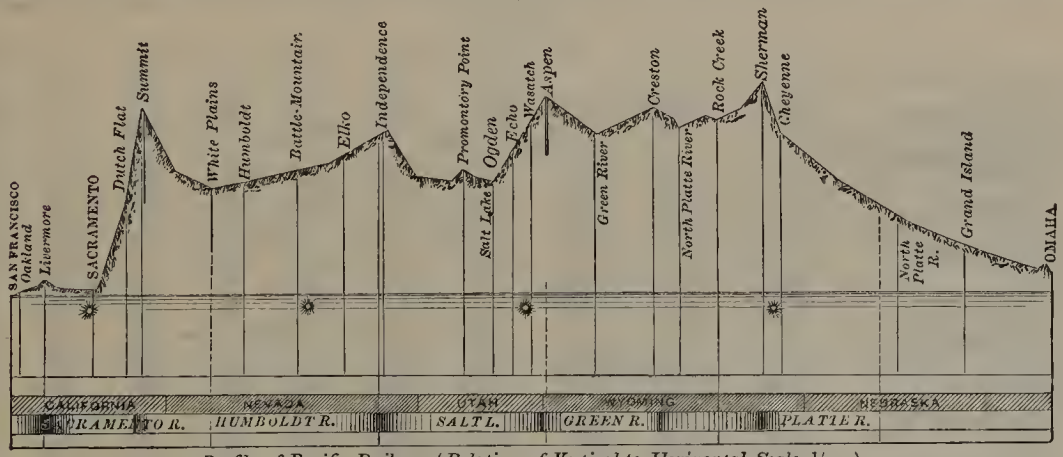
In *fortification*, it is perpendicular to the face of the work. See illustration of *Intrenchment*.

A *profile* is a light wooden frame set up to guide workmen in throwing up a parapet.

In *railroading*, a profile is a vertical section of the country traversed, showing the hills and hollows, and enabling the cuttings and embankments to be so adjusted that the earth of one will furnish material for the other.

The scale of vertical proportion of working drawings is generally ten times that of the horizontal.

Fig. 3968.



Profile of Pacific Railway (Relation of Vertical to Horizontal Scale, $^1/_{4000}$).

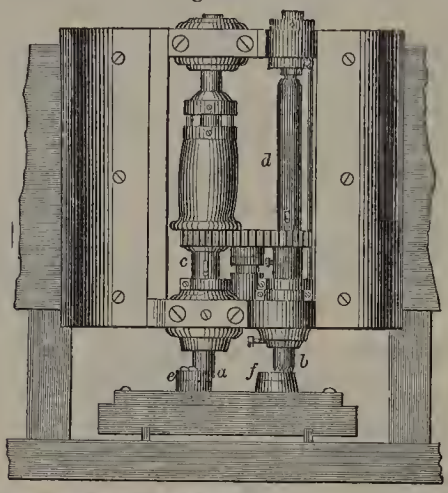
Pro'file-cut'ter. (*Wood-working.*) The cutting-knife, usually made up of sections which correspond to parts of a given pattern of molding, and by which molding is cut in a machine. See MOLDING; MOLDING-MACHINE.

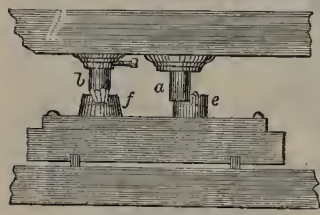
Pro'file-pa'per. Paper ruled with horizontal and vertical lines for drawing profiles of railway surveys, fortifications, or other engineering works.

Pro'fil-ing-ma-chine'. One by which an object of a given contour or outline may be duplicated; or one by which a given profile may be given to a piece by adequate manipulation of the parts, in the

absence of the pattern which forms an automatic guide for the tool. In the former case, the machine

Fig. 3969.





Profiling-Machine.

is used for duplicating templets, gages, and patterns, now so much used in making various machines, a great number to an exact size and proportion, to be afterward assembled. Locomotives, sewing-machines, fire-arms, watches, and many other articles are thus made. (See ASSEMBLING.) The machine shown in Fig. 3969 partakes of some of the characteristics of the CARVING-MACHINE (which see), and also of the LATHE FOR TURNING IRREGULAR FORMS (which see). In each case the principle of action is that of two corresponding mandrels moving in concert, one having a pin which traverses the outline of the object to be copied, and the other having a cutter which moves around the object to be cut in a path corresponding to that of the pin which is guided in contact with the edge of the pattern.

In the instance illustrated, the pin *a* is on the mandrel *c*, and the cutter *b* on the mandrel *d*; these are geared together and rotated, the pin *a* being kept in contact with the pattern *e*, while the cutter is rotated in contact with the work *f* in and out and around as the contour of the pattern may govern the pin.

Pro-jec'tile. A missile, or package containing a number of missiles, projected from a gun by the expansive force of air, gas, or steam; commonly the gases generated by the ignition of gunpowder. See the following under their appropriate heads: —

Ammunition.	Gun-harpoon.
Angel-shot.	Hand-grenade.
Arrow.	Harpoon.
Ball-cartridge.	Incendiary-shell.
Barrel-shot.	Langrel.
Bar-shot.	Light-ball.
Bolt.	Minie-ball.
Bomb.	Nail-ball.
Bomb for killing whales.	Parachute light-ball.
Bomb-lance.	Percussion-shell.
Buckshot.	Rocket.
Bullet.	Rocket-harpoon.
Canister-shot.	Round-shot.
Cannon-ball.	Sabot.
Carcass.	Sand-shot.
Cartridge.	Segment-shell.
Case-shot.	Shell.
Chain-shot.	Shot.
Charge.	Shrapnel.
Crossbar-shot.	Slug.
Double-headed shot.	Smoke-ball.
Expanding-ball.	Spherical case-shot.
Explosive-ball.	Sub-caliber projectile.
Fire-ball.	Tier-shot.
Grape-shot.	Torpedo.
Grenade.	Trundle-shot.

See also PRIMER, SABOT, FUZE, WADDING, PACKING, PERCUSSION-CAP, CHARGER, and the other accessories.

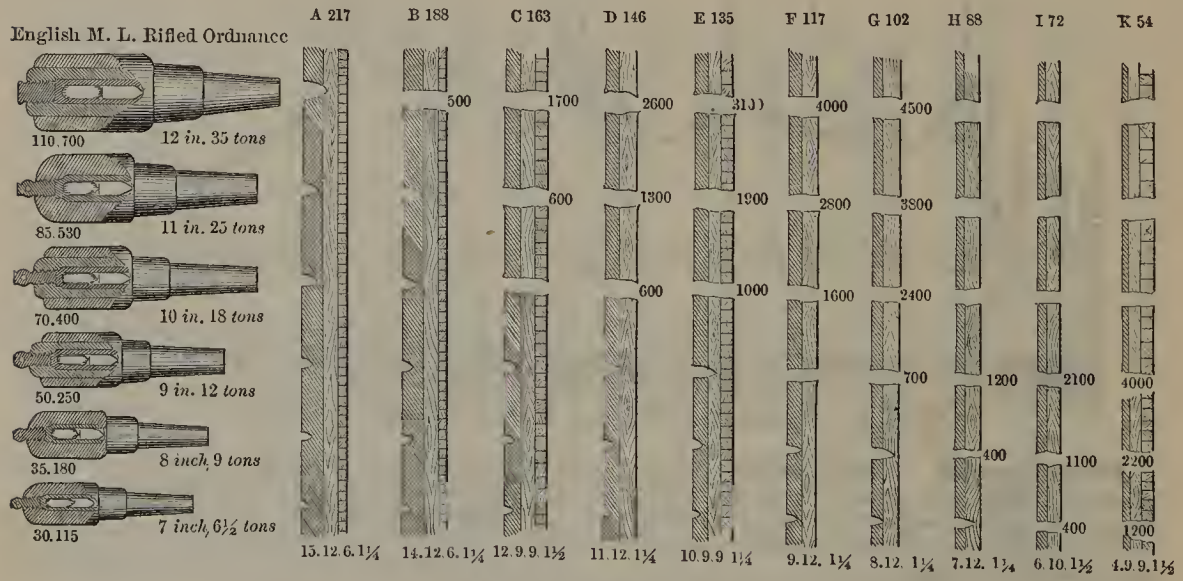
The number of projectiles used in the Crimean war, as compiled from official data, is as follows: French, 29,460,363; English, 15,000,000; Piedmontese, 50,000; Turks, 50 000; Naval forces (Allied), 35,000; Russian, 45,000,000. Total, 89,595,363.

Killed and wounded by these projectiles: French, 50,836; English, 21,038; Piedmontese, 183; Turks, 1,000; Naval forces (Allied), 2,000; Russian, 100,000 Total, 175,057.

One projectile in 512 did execution, upon the supposition that no two projectiles struck one person.

Fig. 3970 is a diagram showing the perforating and penetrating power, at various distances, of Palliser projectiles, fired from the service rifled muzzle-loading guns, with battering charges of pebble powder. Each target, representing in resisting power a certain class of vessel, is supposed to be at the normal distance of 200 yards from the gun, except where the range at which the projectile would perforate such a target is expressly stated. Thus the diagram shows that a target consisting of a 14-inch plate, backed by 18 inches of timber, and a 1¼-inch iron skin, would be perforated at 500 yards by the 12-inch 35-ton gun; whereas the Palliser projectiles fired from

Fig. 3970.



Penetration of Projectiles.

the 11-inch 25-ton gun would only penetrate to a depth of 16 inches into the same target at 200 yards.

The weights of guns and force of impact are expressed in English tons of 2,240 pounds. The figures under each gun are respectively: —

Weight of powder. Diameter of bore.
Weight of ball. Weight of gun.

The figures opposite the holes through the targets are the distances in yards up to which the shot made a clean breach.

The power of resistance of each target is given immediately over it; thus A 217 means that it would require an energy of 217 foot tons per inch of the shot's circumference to perforate class A. All projectiles are assumed to strike perpendicularly to the face of the target.

The figures beneath the armor are the thicknesses of the plating, backing, and skin.

Pro-jec'tion. (*Drawing.*) The representation on a plane surface of the parts of an object.

The *gnomonic* projection. The eye is placed in the center of the sphere.

The *orthographic* projection. The eye is supposed to be at an infinite distance.

The *stenographic* projection. The eye is placed on the surface of the sphere.

The *isometric* projection. The projections of three equal lines parallel respectively to three rectangular axes are equal to one another.

The *perspective* projection. Represented on the perspective plan.

Pro-lap'sus-in'stru-ments. *a.* Instruments used to correct or prevent the falling of the womb. See PESSARY; ABDOMINAL BANDAGE, etc.

b. To prevent the falling of the anus; a trap-like appliance, consisting of a pelvic band to which is fastened a spring running down the spine and ending in an ivory pad resting on and supporting the anus. See also SUPPOSITORY; PILE-SUPPORTER.

Pro-longe'. (*Ordnance.*) A rope used to drag a gun-carriage without the limber in maneuvering when it is required to move in a narrow track, or in retiring firing along a street or through a defile. It has a hook at one end and a ring at the other.

Pro-me'the-an. A device for striking light, consisting of matches tipped successively with melted sulphur and then with chlorate of potash to inflame them. They are dipped in a bottle of sulphuric acid. See LIGHTING-DEVICES.

Prong. In a mechanical sense this is equivalent to a *tine*, a *claw*, a *tooth*, as the relation may require or suggest.

Prong-chuck. A burnishing chuck with a steel prong.

Proof. 1. (*Printing.*) A trial impression from a form for examination by the reader and comparison with the copy. (*First proof.*)

After correction a second proof is taken for the author. (*Clean proof.*)

The corrections and alterations having been attended to, a third proof (the *revise*) is had, to see that the alterations have been correctly made.

A *press-proof* is a final one to settle the margins, signatures, etc.

2. (*Engraving.*) *a.* An impression taken from a steel or copper plate in the course of its execution to determine its forwardness.

b. A *counter-proof* is an impression taken from a newly printed proof, to obtain a copy from an engraved plate similar to the latter and not in reverse.

c. An early impression of a completed plate before the printing of the regular edition.

3. (*Spirits.*) A mixture of equal weights of absolute alcohol and water. Its specific gravity is 0.917. The ordinary proof-spirit of commerce is 0.920 at 60° Fah.

The name is derived from the gunpowder-proof. Spirit was poured over gunpowder and the vapor inflamed. If it fired the gunpowder, it was *over* proof. If it damped the powder, so that the spirit burnt without igniting the powder, it was *under* proof. The weakest spirit capable of firing gunpowder was the proof-spirit of pharmacy, specific gravity 0.920.

4. (*Ordnance.*) The tests are by hydraulic pressure and by firing charges.

The proof charge is much heavier than the service charge, and is repeated, close examination being made for flaws and crevices.

The proof by water is under a heavy pressure; the bore being wiped dry, the surface is examined by a mirror to detect the exudation of moisture from crevices or honeycomb.

5. (*Small-arms.*) The barrels are loaded with a heavy charge, laid on a massive table in the proving-room, and fired by means of a train of powder, the balls being received in a sand-bank. This is repeated.

The proving of gun-barrels at Ilion is thus performed: forty barrels are loaded at a time, with 280 grains of powder and 500 grains of lead in each, and arranged in a small room, to be all discharged at once; they are placed in position, wedged, and held down by a heavy beam; a train of powder is then laid to all the touch-holes, the workmen leave the room, and all is ready; the double doors having been closed, the tester strikes with a hammer a small rod of iron protruding through the wooden partition: the rod is driven into a percussion-cap at the end of the train of powder, and the explosion of the charges in all the rifles immediately occurs. The value of this test is very great, the ordinary charge being 70 grains of lead. The barrels are afterward tested with 150 grains of powder, to see if they have been strained by the first test.

Swords are proved by bending them and seeing if they resume their original shape, and by striking them flatwise over a curved block of hard wood.

6. (*Gunpowder.*) *a. Ordinary proof of powder;* one ounce with a 24-pound ball. The mean range of new, proved at any one time, must not be less than 250 yards; but none ranging below 225 yards is received.

Powder in magazines that does not range over 180 yards is held to be unserviceable.

Good powder averages from 280 to 300 yards; *small grain*, from 300 to 320 yards.

b. A proof of blasting-powder is, that two ounces being fired in an 8-inch mortar, elevated at an angle of 45°, shall throw a ball of 68 pounds to a distance of 240 feet.

Another test is, that two ounces of powder in the eprouvette gun (weight, 86½ pounds; bore, 27.6 inches long and 1¾ inches diameter) shall give a recoil of 20°.

7. (*Sugar-manufacture.*) The test by which a sugar-boiler judges of the condition of the condensed sirup.

The *preuve au filet*, or *string test*, consists in taking a drop of sirup between the finger and thumb and then separating. The condition required is that the sirup will allow itself to be drawn into an attenuated thread.

The *preuve au crochet*, or *hook test*, is when the thread breaks and curls up into a little hook. This is divided into the *crochet leger*, or *weak*, and the *crochet fort*, or *strong*, according to the energy of the action in forming the hook.

The *preuve au soufflé*, or *bubble test*, is obtained by taking a portion of sirup in a perforated skimmer and blowing from below upward so as to make a bubble of sirup. The abundance and size of the bubble determine whether it be *soufflé leger* or *soufflé fort*. It indicates a condition fit for making candy.

The *preuve au caisse*, or *case proof*, is by dipping the wetted finger in sirup and then in cold water, taking up a *case*, or *sheath*, of sirup, whose behavior when rolled into a ball and thrown upon the floor determines the classification, as follows: *le petit caisse* is when the ball of sugar rolled from the finger is cracked open by throwing it on the ground; *le grand caisse* is when the ball flies to pieces under the same circumstances; *le caisse sur le doigt* is when the envelope of sugar on the finger refuses to roll, but breaks up as it is removed.

M. Payen has given precision to these tests by describing their respective temperatures and density.

Tests.	Temperature, Fah.	100 parts contain —	
		Sugar.	Wat'r.
Filet	228 2	85	15
Crochet leger	230.9	87	13
Crochet fort	233.6	88	12
Soufflé leger	240 8	90	10
Soufflé fort	249.8	92	8
Caisse petit	251 6	92 7	7 3
Caisse grand	263.3	95 7	4 3
Caisse sur le doigt	270.5	96.5	3.5

8. (*Proof of Strength.*) See DYNAMOMETER; TESTING-MACHINE.

9. Iron axles are proved by allowing them to fall from a certain hight upon two blocks of cast-iron, or by letting a weight fall upon them from a certain hight.

Proof-house. A house fitted up for *proving* barrels of fire-arms. They are extra heavily charged, laid on a bench, primed, and fired by a train of powder into a bank of sand. The average loss in England is four per cent on 600,000 barrels annually. A second proving takes place when the piece is ready for assembling.

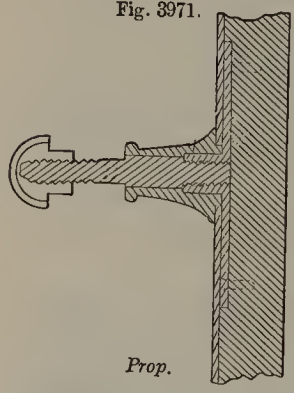
Proof-plug. A plug screwed temporarily into the breech of a gun-barrel to be proved.

Proof-sheet. (*Printing.*) An impression taken for the use of the corrector or author after all errors noted have been corrected.

Proof-staff. A metallic straight-edge by which a wooden staff is tested and corrected, *e. g.* the *red staff* used by millers to detect irregularities in the face of a millstone. The straight-edge, being reddened with ocher, is passed over the face of the millstone, and the elevated points become colored in consequence.

Proof-stick. (*Sugar-making.*) A stick with which a small quantity of sirup is lifted from the open pan or the vacuum-pan to judge, by the rapidity and character of its crystallization, the condition of the contents of the pan. See PROOF, 7.

Fig. 3971.



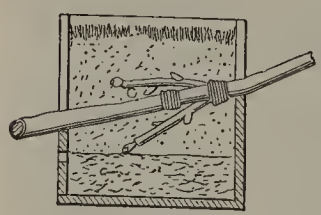
Prop.

Prop. (*Vehicle.*) A stem fastened to the carriage bow for the attachment of the stretcher-piece, known as the *prop-joint*, and upon which the bows rest when down.

In the example, the inner plate has a square, tubular, projecting socket, which receives the screw-shank of the prop. An outer collar fits on the square socket, and on a square portion of the prop, so that the latter cannot rotate.

Prop'a-gat'ing-box. A box in which a cutting is placed to germinate. In the example, it is one of a series of boxes having slots down their sides in order that a grape-vine, for instance, may be laid along the row of boxes and layers, obtaining plants by the striking of roots at the joints of the vine.

Fig. 3972.



Propagating-Box.

Prop'a-gat'ing-glass. A hand-glass to cover small plants.

Pro-pel'ler. A means for the propulsion of vessels. The varieties may be classed as follows: —

1. Paddle-wheels.
   - *A.* On horizontal shaft or shafts.
     - *a.* Fixed paddles.
     - *b.* Feathering paddles.
     - *a'.* Turning on horizontal axes.
     - *b'.* Turning on radial axes.
     - *c.* Sliding paddles; moving toward and from the paddle-wheel shaft.
     - *d.* Paddles attached to traversing chains.
     - *e.* Paddles attached to cranks.
     - *f.* Collapsing paddles.
     - *g.* Paddles in reciprocating frames.
     - *h.* Sculling paddles.
     - *i.* Cycloidal paddles.
   - *B.* On vertical shaft.
2. Hydraulic propeller.
3. Screw-propeller.
4. Rope-traction.
5. Spike-wheel.
6. Pole-propeller.
7. Rack and pinion propeller.
8. Wave-power propulsion.
9. Oars.
10. Sails.

The boats by which the Roman army under Claudius Codex were transported into Sicily were propelled by wheels moved by oxen. The substitution of paddles for oars is mentioned in many old military treatises Thomas Savery, in England, obtained a patent, in 1696, for a paddle-wheel on each side of a ship, to be turned by means of a capstan.

In the "Vitruvia de Architectura," folio, Como, 1521, there is an engraving of a large vessel propelled by paddles worked by animal power. A pen-and-ink sketch on an Italian manuscript of the fifteenth century, preserved in the British Museum, shows a vessel propelled by a pair of paddle-wheels on a shaft rotated hy gearing and hand-power. From 1619 to 1662, six patents were granted in England for devices purposely described with great looseness, for concealment, but which appear to have been paddle-wheels of some kind.

In 1690, Papin describes "oars fixed to an axis," a pinion on the latter being engaged by a rack on the piston-rod.

In 1729, Dr. John Allen patented the hydraulic propeller, forcing water through the stern of the ship at a convenient distance under water.

In 1737, Jonathan Hulls patented a steamboat propelled by a paddle-wheel astern.

In 1738, David Ramsey obtained a patent in England for a mode of propulsion of vessels by the force of water ejected by a steam-pump.

In 1780, Watt suggested the *spiral oar* to move canal-boats.

In 1780, the present arrangement of connecting-rod crank and fly-wheel was patented. In the same year the Marquis de Jouffroy worked a steamboat 140 feet long on the Saône.

In 1782, Rumsey propelled a freight-boat on the Potomac by means of the hydraulic propeller. A steam-engine worked a vertical pump amidships; the water was drawn in at the bow and expelled through a trunk astern.

In 1785, Joseph Bramah patented a rotatory engine on a propeller-shaft.

In 1786, Fitch had a steamboat on the Delaware, propelled by paddles like those of an Indian canoe.

In 1786, Benjamin Franklin and Oliver Evans advocated the hydraulic propeller, receiving the water forward and forcing it out astern.

In 1787, Patrick Miller patented, in England, paddle-wheels for propulsion.

In 1788, Fitch ran his boat by means of reciprocating paddles.

In 1788, Symington had a steamboat on the lake of Dalswinton, propelled by an engine and side paddle-wheels.

In 1789, Symington had a boat on the Forth and Clyde Canal, propelled by an engine, and a pair of paddle-wheels placed amidships, respectively fore and aft the engine, and working in a trough extending from stem to stern of the boat, over the keel.

In 1789, Oliver Evans, of Philadelphia, had a stern-wheel steamboat which navigated the Schuylkill.

In 1795, Lord Stanhope invented the "duck-feet paddles," and ran a boat three miles an hour.

In 1796, Fitch had a steamboat on Collect Pond, New York, propelled hy a screw astern.

In 1802, Symington's double boat, "Charlotte Dundas," was propelled by one middle paddle-wheel abaft the engine and working in the space between the twin boats.

Fulton's and Bell's steamboats had side paddle-wheels, as also the "Savannah," 1819, "Enterprise," 1825, "Great Western" and "Sirius," 1838. The "Great Britain," 1843, had a screw, and after this the screw became common. See PADDLE-WHEEL

The term *propeller* is usually applied to the longitudinal revolving shaft with vanes or wings, and more specifically known as the *screw propeller*.

The first use of the propeller was by Stevens, of Hoboken, who used twin-bladed screws in 1804. See SCREW-PROPELLER.

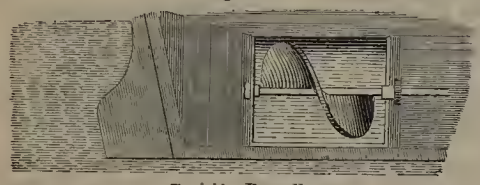
The bladed screw-propeller was brought forward by Ericsson in 1836, and the spiral screw in the *dead-wood* was patented by F. P. Smith.

Captain Robert F. Stockton, United States Navy, and Francis B. Ogden, of New Jersey, became interested in Ericsson's invention, and the propeller "Francis B. Ogden" was launched on the Thames, and made trips as early as May 28, 1837. An iron vessel, the "Robert F. Stocktou," fitted with a screw-propeller, was launched into the Mersey, July 7, 1838. She was the second screw-propeller in England, as the "Francis B. Ogden" was the first. She crossed to the United States the next year, received an American register, was re-named the "New Jersey," and was the first screw-propeller (excepting the small, twiu-screw propeller of Stevens) in American waters. Ericsson's patent was July 13, 1836, and his propeller had spiral blades, the preferable form.

The first propeller war-steamer was the "Princeton," launched into the Delaware.

Francis P. Smith's name is intimately associated with the introduction of the propeller. His pateut is dated May 31,

Fig. 3973.



Smith's Propeller.

1836. He was the first to make it a continuous screw and to place it in the dead-wood. His screw was attached to the "Archimedes" in 1839.

Of the four cigar steamers of Messrs. Winans, the propeller of the first was placed around amidships; the second, beneath; the third is fitted for trying in various positions; the fourth has a propeller at each end.

In 1863, the "Far-East," a propeller with two screws, was launched at Millwall, England.

The screw-propeller generally consists of a *boss* fitted upon the end of a propeller-shaft, and with two or more *blades* arranged symmetrically around it, so as to balance each other.

The propeller is said to *overhang* when it has no after bearing in the *after* stern-post or rudder-post.

The propeller may be made to rise out of the water when the ship is under canvas alone. In this case it is detached from the shaft and drawn up into a *screw-well* in the stern of the vessel.

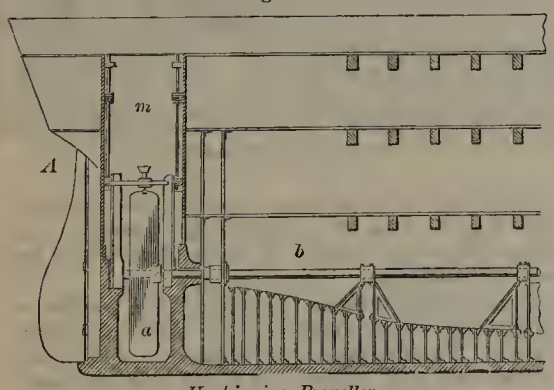
The *pitch* of a propeller-screw is the length, measured along the axis, of a complete turn.

The *speed* of the propeller means the pitch multiplied by the number of turns in a unit of time; or the speed may be stated in the number of revolutions of the propeller-shaft per minute, where *pitch* does not enter into the computation.

The effective *area*, or *disk*, of a screw-propeller is measured in a thwartship plane, and has for its outer boundary the circle swept by the tips of the blades, and for its inner boundary the outline of the boss.

The *slip* of a propeller is the difference between its rate of progression, the length of its pitch to each revolution, and the actual progress of the vessel through the water.

Fig. 3974.



Unshipping-Propeller.

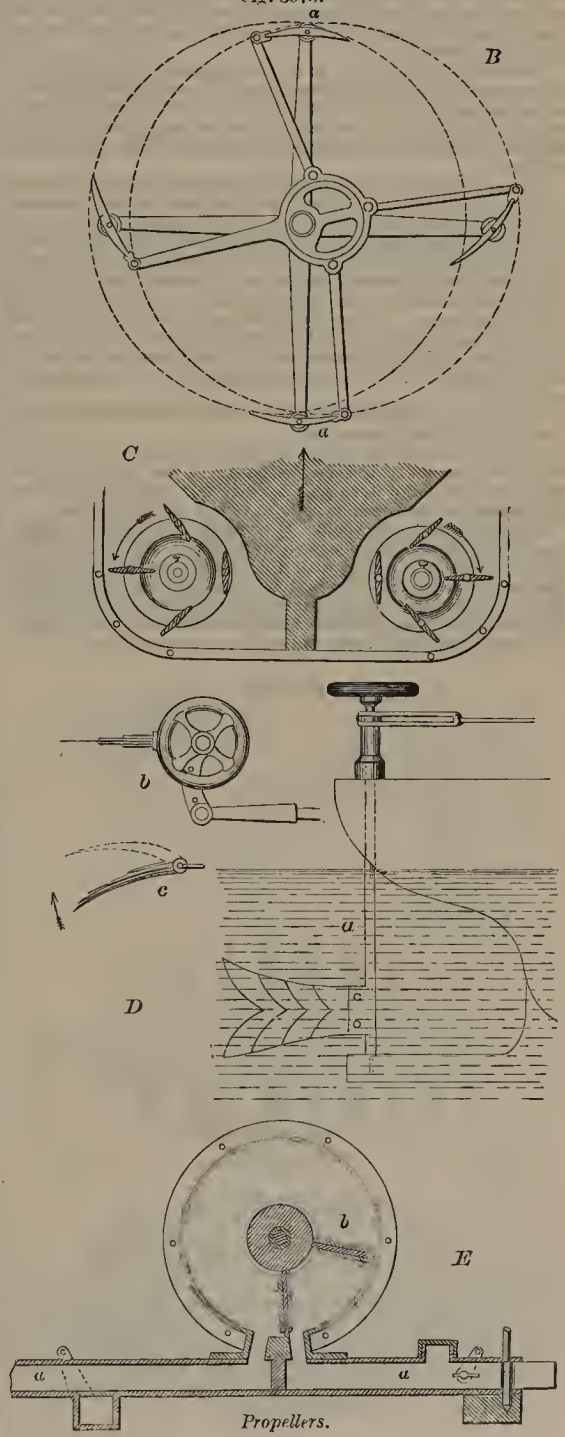
Screw-propellers are known as *adjustable, unshipping, auxiliary, twin* or *double, gaining.*

Woodcroft introduced the increase-pitch or *gaining-screw* propeller; the pitch gradually gaining from the *leading* to the *following* edge.

When twin-screws are used, one screw is *right-handed* and the other *left-handed*, so that, being turned in contrary directions in driving ahead, they may counteract each other's tendencies to produce lateral vibration.

Griffith's had a hollow spherical ball, forming an enlargement of the hub, being substituted for the central portion of the blades. The blades taper toward the extremities. The pitch

Fig. 3975.



Propellers.

is alterable, by the rotation of each screw on its stem, which is radial to the main shaft.

Ericssou's blades were on the exterior of a cylinder.

James Montgomery's propeller has a cylindrical rim around the outer edges of the wings, to prevent radial projection of the water and strengthen the wings. Patented April 12, 1859.

A (Fig. 3974) shows a section of a three-decked vessel with a screw-propeller. To disconnect the propeller when the ship is under canvas, it is lifted into a hollow trunk *m* constructed over it in the stern of the vessel, entirely out of the water, the outer screw-shaft fitting into a vertical frame of gun-metal which rises along with it. The screw *a* is disconnected either by withdrawing the driving-shaft *b* out of a socket in the screw-shaft, or, which is the better plan, by forming a coupling on the end of the driving-shaft, into which the screw-shaft fits and adjusts itself when slipped down between the guides and trunk. The screw is then retained in its position by a catch pressed down from above upon the gun-metal frame supporting the bearings, as well as by its own weight. The screw is raised into or through the trunk by pulleys and ropes worked by a capstan, the weight of the screw and its shaft being supported by a pawl and rack on each side of the trunk. In some cases, the screw is only capable of being disconnected from the engines, and left free to revolve by the action of the water upon it, from the motion of the vessel.

Maudslay's substitute is a feathering contrivance, applicable only to two-bladed screws, consisting in placing the blades in a fore-and-aft direction, so that they may lie within the dead-wood of the vessel and present little or no projecting surface to impede her progress or affect her steering. See SCREW-PROPELLER.

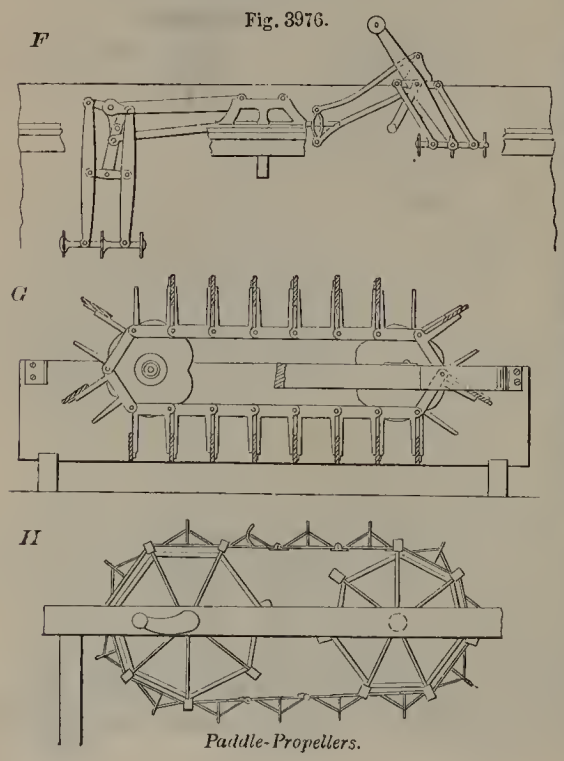
Fowler's steering-propeller (*B*, Fig. 3975) is a submerged wheel turning on a vertical shaft, with paddles which are feathered by an eccentric cam, in such manner that the paddles shall have a pushing and drawing action on the water while passing through the sectors shown by dotted lines, and present only their edges to the water while passing the points *a a*, which may be called dead-points so far as their influence in the propulsion of the ship is concerned. By turning the cam-wheel, which is done by "the man at the wheel" by a simple connection, the feathering is done at different points, and the ship may be backed or turned round and round on her center without reversing the engine.

A propeller of this kind is in use in one of the new torpedo-boats of the United States Navy.

Hunter's steering-propeller *C*, patented 1874, is similar to the Fowler propeller in some respects. It has two wheels on opposite sides of the stern-post, revolving in opposite directions. The blades are feathered so as to have but one dead-point.

Hunter's fish-tail propeller *D* consists of a flexible attachment to a post *a* at the stern of a ship The propeller vibrates from side to side with the revolution of the engine. The leaves of the propeller may be of rubber or thin metallic plates. The shape the propeller assumes while in motion is shown at *c*, and the pressure of first one side and then the other obliquely against the water causes the vessel to advance.

Fig. 3976.



Paddle-Propellers.

The hydraulic propeller so often projected — by Allen, in 1729; Hulls, 1737; Ramsay, 1738; Rumsey, 1782; Franklin and Evans, 1786 — has been lately revived, the English government vessel the "Water-Witch" being propelled by a rotary pump taking in water at one end and expelling it at the other. The vessel is double-ended. *E* is a modified form of this propeller. *a a* is the passage by which the water enters and leaves the pump-chamber.

Fig. 3976 shows propellers with paddles. *F* is a form of propeller whose floats are carried on the ends of levers, which lift them out of the water on the completion of their stroke, at the same time dropping into the water the corresponding set at the other end of the compound lever.

G H are forms of propellers in which the floats are carried on endless chains, which pass over wheels propelled by the engine.

See Browne's "Treatise on the Screw-Propeller," London, 1867; Burgh's "Modern Screw Propulsion," London, 1869.

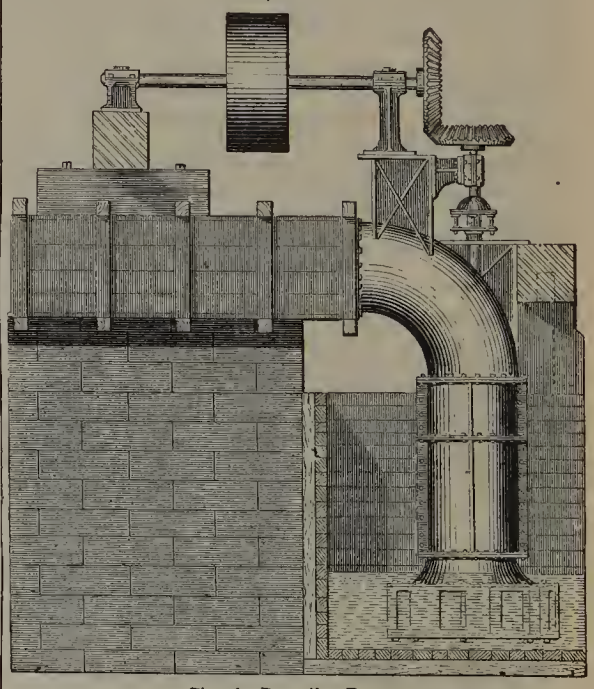
See under the following heads: —

Archimedean-screw propeller.	Propeller-engine.
Auxiliary screw.	Propeller-wheel.
Duck's-foot propeller.	Rack and pinion propeller.
Elastic propeller.	Rail and traversing-wheel propeller.
Endless-chain propeller.	Reciprocating propeller.
Fish-tail propeller.	Rope-traction propeller.
Hydraulic propeller.	Screw-propeller.
Nautilus-propeller.	Spike-wheel propeller.
Oar.	Traveling-belt propeller.
Oar-propeller.	Wave-power propeller.
Paddle-wheel.	Windmill-propeller.
Pole-propeller.	

Pro-pel'ler-en'gine. The introduction of the screw-propeller has brought into use a new class of engines of short stroke, a number being ranged in a line coincident with the line of the propeller-shaft. For this service the oscillating-cylinder engine is peculiarly adapted. See OSCILLATING-CYLINDER ENGINE; SCREW-PROPELLER ENGINE.

Pro-pel'ler-pump. A form of rotary pump in which the wheel resembles the propeller-wheel of the marine service. It is driven by band-shafting

Fig. 3977.



Shaw's Propeller-Pump.

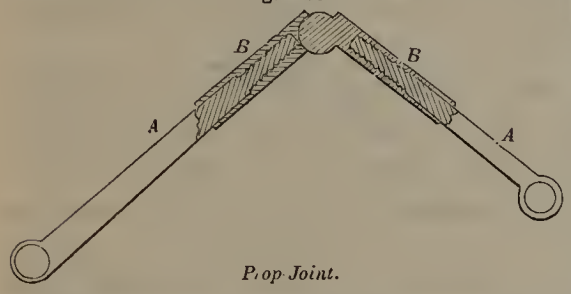
and gearing in a direction to *gather* the water and force it upward in the vertical tube; interior radial wings direct the column of water upward and prevent its acquiring a vortical motion.

Pro-pel'ler-wheel. The blades are sections of spiral flanges winding around the shaft like screw-threads. The rotation of the shaft causes the blades to bear obliquely against the water, and produces a

motion of the vessel in the direction of the axis of the screw. Generally called a screw-propeller. See PROPELLER; SCREW-PROPELLER.

Prop-joint. (*Carriage.*) The jointed bar which spreads the bows of a calash-top. Its ends are socketed upon the *props*, known technically as *top-props*. The portions *A* are attached by welding or otherwise to the portion *B*, which is known as the *stub-joint*.

Fig. 3978.



Prop-Joint.

Pro-por'tion-al Com'pass-es. This instrument is used for copying drawings on a larger or a reduced scale. The pivot is secured in a slide which is adjustable in the slots of the legs, so as to vary in any required proportion the relative distances of the points at the respective ends. The legs are provided with marks by which the ratio of proportion of the respective ends may be arranged or determined. One side may be graduated in powers of 2; another in an ascending series, $\frac{1}{10}$, $\frac{1}{9}$, $\frac{1}{8}$, $\frac{1}{7}$, $\frac{1}{6}$, $\frac{1}{5}$, $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, etc.

Fig 3979.

Proportional Compasses.

A pair of compasses, the arms of which are as 1 to $3\frac{1}{7}$, will denote approximately the proportion between the diameter and circumference of a tube, so that, the diameter being measured by the shorter arm, the longer will denote the width of the strip of metal required to produce it.

Pro-por'tion-al or Prim'i-tive Ra'di-i. (*Gearing.*) If the line of centers connecting the centers of two wheels in gear be divided into two parts, proportioned to the number of teeth in the respective wheels, the said two portions will be the proportional or primitive radii.

The *true* radius of a wheel is the distance from the center to the circumference.

Prop-stay. A transverse water-tube crossing a boiler-flue, forming a passage for the water and increasing the flue-surface by the exposure of its exterior surface to the heated current.

The most notable instance of the use of *prop-stays* is in the Galloway boiler, which has *tubes* crossing the *flues*. See TUBULAR BOILER.

Prop'y-læ'um. (*Architecture.*) A portico in front of a gate or temple doorway.

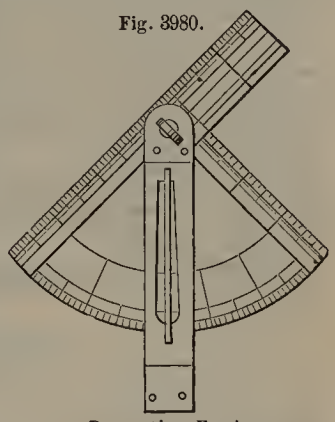
Pros'o-pom'e-ter. (*πρόσωπον*, the countenance; *μέτρον*, a measure.) An instrument for measuring the superficies of the head and face, thence to deduce the cubic contents of the cranium.

Pro'te-an-stone. A preparation of gypsum, resembling alabaster. By a peculiar process the gypsum is made to assume a semi-translucent appearance, and is then wrought into form or powdered and pressed into a mold. It is then oiled or varnished.

Pro-tec'tive Pa'per. Paper made to prevent tampering with the printing or writing subsequently put upon it. A means of preventing or detecting fraud. Water-marks are made in paper for this purpose. Paper is also made with distinguishing marks, by which it may be identified. See SAFETY-PAPER.

Pro-tract'ing-bev'el. A plotting-instrument having a protracting sector and a prolongation of one radius, which forms a rule. In Fig. 3980, the bevel-stock is pivoted to the protractor, at the center of the circle of which its curved edge is an arc, and has an oblong slot, divided longitudinally by a small metallic strip, which serves as an index to the graduated arc beneath.

Fig. 3980.



Protracting-Bevel.

Pro-tract'or. 1. An instrument for laying down angles on paper, etc. They are either of rectangular, semicircular, or circular shape, and are made of paper, ivory, horn, or metal.

a is the ivory or boxwood protractor usually embraced in a case of mathematical instruments. It is about six inches in length; the ends and one side are beveled, and are graduated from 0° to 180°. Its face has one or more diagonal scales for setting off distances.

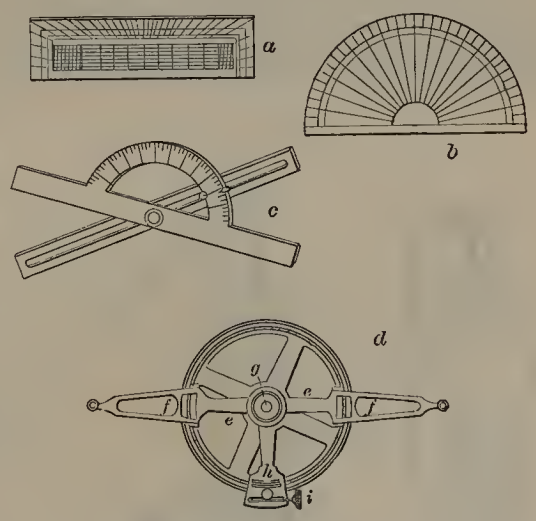
b is a semicircular protractor of transparent horn. This is a very useful instrument in some cases, enabling the draftsman to see the surface of the paper beneath.

c. A metallic *bevel* protractor.

d is a circular metallic protractor.

Each end of the arm *e e* is provided with a vernier, reading usually to minutes, and carries a light frame *f f*, having a button on its upper and a finely pointed pin on its lower side; these frames have sufficient spring to keep the pins clear of the paper as the arm is turned on its axis. The center of the instrument and the two pins lie in the same straight line; the former being usually indicated by the intersection of two fine cross-lines engraved on a plate of transparent material in the opening *g*; *h* is an arm provided with a vernier and carrying a set-screw by which the arm may be clamped to the circle while a slight movement is imparted to it by means of the tangent-screw *i*. The graduations may extend from 0° to 180° each way, may be continued round the circle from 0° to 360°, or both graduations, one exterior to the other, may be employed.

Fig. 3981.



Circular Protractor.

In use, the center of the protractor is placed immediately over

the point from which the angular distance is to be measured; the arm *e e* is turned to coincide with the line forming one side of the angle and adjusted by the tangent-screw until the pins are brought exactly over this line, when they are depressed, forming two minute dots in the paper; the arm is then unclamped, set approximately to the required angle, again clamped, the verniers, by means of the tangent-screw, caused to indicate the exact angle to be laid off, and the pins pressed down into the paper as before; the protractor being removed, a straight line may be drawn between the two points first laid down, and another between the two last pricked into the paper; if the instrument is in correct adjustment these should intersect exactly at the central point.

A rude sort of protractor may be made by doubling a square piece of paper diagonally from corner to corner; this gives an angle of 45°, which may be again subdivided by doubling into angles of 22° 30′, 11° 15′, etc.; these correspond to the rhumbs of the mariner's compass.

"This parallelogram [pantograph] is not the same as a *protractor*, but is a most useful instrument." — PEPYS's *Diary*, February 4, 1669.

2. (*Tailoring.*) An adjustable tailor's pattern, expansible to agree in its proportions with the particular measnrements and capable of being secured in the obtained adjustment.

Prov'ing. An experiment to test the strength of anything.

Of gunpowder, see EPROUVETTE; BALLISTIC PENDULUM.

Of barrels, see GUN-BARREL.

Of ordnance, see CANNON; PROOF.

The *proof* of spirit is ascertained by a HYDROMETER (which see).

The *proof* of a form or engraving is a trial-impression.

The *proof* of horizontality, see LEVEL.

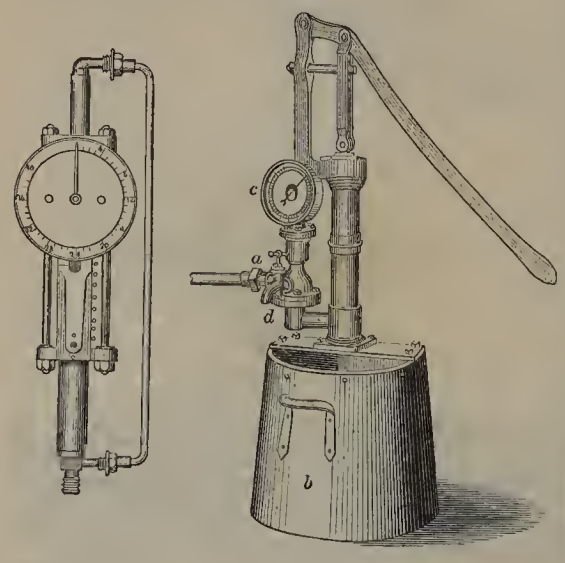
Of flatness, see PROOF-STAFF.

Prov'ing-hutt. See PROOF-HOUSE.

Prov'ing-ma-chine'. One for testing the resistance of springs or the strength of materials. See TESTING-MACHINE.

Spencer's machine for proving india-rubber springs by compression consists essentially of a stroug iron frame, the top of which is provided with two longitudinal guide-bars; between these are arranged two sliding-plates, one of which is operated by a horizontal screw and lever, and the other rests against a piston in the frame whose end presses against the shorter arm of one of a system of three levers: the long arm of the lowest lever is connected with the hook of a spring-balance. The spring to be tested is inserted between the two plates and pressure applied by the screw, causing the spring to react against the piston, which communicates the pressure to the compound levers, its amount being indicated by the spring-balance. Springs having a power of twenty tons may be tested by this machine.

Fig. 3982.



Proving-Pump.

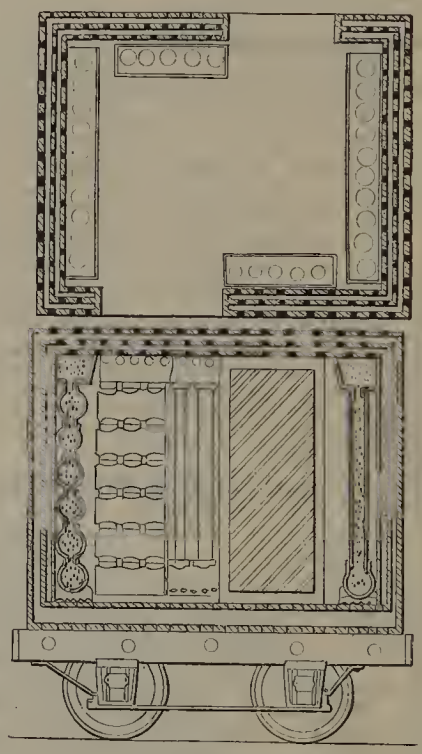
Prov'ing-press. One arranged to test the strength of iron girders, etc.

Prov'ing-pump. A forcing-pump for testing boilers, tubes, etc. The object to be proved is connected to a coupling *a*, and water from the bucket *b* is forced into it by operating the lever; the amount of pressure is indicated by the gage *c*. A cock *d* is provided for drawing off the water after testing.

On the left is a differential pressure-gage, in which the force of the water from the pipe is brought upon an upper and a lower piston in two cylinders, the difference between the motions of the two being communicated to the rack which operates the pinion on the arbor of the dial-hand.

Pro-vis'ion-car. One specially constructed for preserving and transporting provisions, meats, etc. In Fig. 3983 the preserving-chambers are surrounded by non-conducting walls, floor, and ceiling. These chambers are cooled by pipes communicating with

Fig. 3983.



Provision-Car.

an ice-chamber and drain-traps. The pipes may have perforations allowing the cool air to flow out into the preserving-chamber, and the air from this chamber, passing into the ice-chamber and through the pipes, establishes an endless circulation.

Prow. (*Shipwrighting.*) The stem or forward post of a vessel. It is *scarfed* to the *keel*, supports the bowsprit, and is the forward point of attachment for the *strakes*.

Pru-nel'la. (*Fabric.*) A smooth, woolen, dark-colored stuff, used as lasting, for making the uppers of shoes and gaiters. *Prunello.*

Prun'ing-chis'el. A chisel for pruning trees.

Fig. 3984.

Pruning-Chisel.

The example has a concave edge to prevent its slipping off the bough.

Prun'ing-hook. A cutting tool with a hooking blade, used in trimming trees, shrubs, and vines. The references to pruning, in Scripture, are numerous, but the pruning-hook is, on each of the occasions on which it is mentioned, spoken of in reference to its conversion into a spear (Joel), or from a spear (Isaiah and Micah). It was probably a heavier tool than our pruning-knife, and cut by a blow, like a bill or machete. See Fig. 679, page 282.

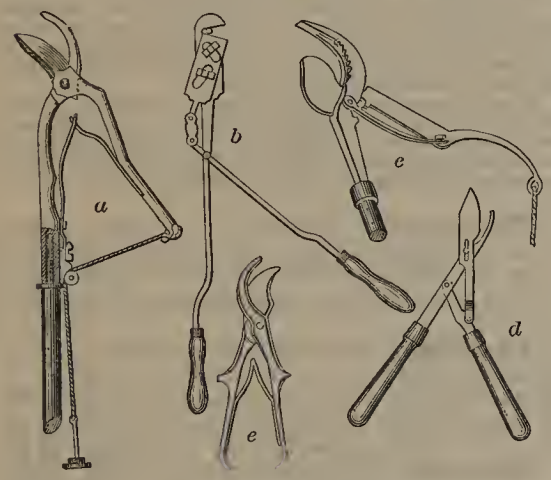
Prun'ing-knife. A knife with a concave edge used for pruning. See *b*, Fig. 3986.

Prun'ing-saw. The pruning-saw is set in a stock of buckhorn, and has double teeth sharpened to points on alternate sides. The edge is thicker than the back, which answers for a *set*. See *c*, PRUNING-TOOLS.

Prun'ing-shears. (*Husbandry.*) A jaw-tool for trimming trees, shrubs, and hedges, pruning fruit-trees, vines, etc.

Fig. 3985 shows several forms: —
a is socketed on the end of a pole, and the movable jaw is worked by a cord and retracted by a spring.
b has a chisel which is thrust endwise against the apposed jaw, being moved by a lever and toggle.
The blade of *c* shuts into a slot in the opposite serrated jaw.

Fig. 3985.



Pruning-Shears.

In *d* the parts are so swiveled together on two centers and a sliding joint as to make a *draw-cut*.
e is a single-handed implement.

Prun'ing-tools. The tools used in pruning are the knife, saw, chisel, mallet, bill-hook, and shears. To these may be added a sword-like instrument, such as a corn-knife or machete.

a is a combined implement, having a cutting-hook, a chisel, and a saw.

The knife *b* has a curved blade, and its tang is set fast in a handle. In another form, the blade shuts into a handle. The sizes and shapes vary. The shape represented is adapted for cutting osier willows and trimming vines.

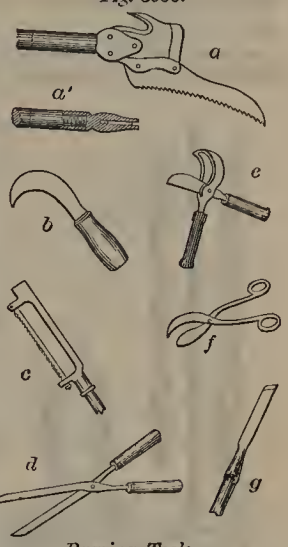
Pruning-saws are fine or coarse, according to the work. A saw is sometimes placed on the end of a pole, so as to sever a limb from a standpoint on the ground.

In *e* the pruning-chisel is placed at the end of a long handle, in which position it may be combined with a saw.

For the lopping tools which act by a blow, see BILL-HOOK.

The pruning-shears are made in several forms.

Fig. 3986.



Pruning-Tools.

d. The shears resembling large scissors with tangs inserted in wooden handles.

e. With a blade opposed to a serrated hook, which holds the branch while the blade severs it. By making the blade cut between two hooks, the tendency of the branch to bend in cutting and pry the jaws apart is avoided.

f. The pruning-scissors has two blades, one being hooked to keep the branch from slipping away. By slotting one of the parts for the passage of the other and making a link connection between the two, the blade is made to give a *draw-cut* in closing, which is favorable to its efficiency.

g is a pruning-chisel, usually placed on the end of a long handle.

"The name of Martius, a friend of Augustus, has been handed down to us as that of the individual whose predilection for unnatural constraint first introduced the custom of cutting and training trees into artificial imitations of architectural and plastic models." — HUMBOLDT.

Pry'an. (*Mining.*) Ore which breaks up into small pebbles with a mixture of clay.

Psal'ter-y. (*Music.*) An ancient stringed instrument of the harp order; probably of a triangular shape and struck with a plectrum. See PIANOFORTE.

The psaltery is shown in two forms in Plates LXV., LXVI., Bonanni's "Istromenti Armonici," Roma, 1776. In each it has a series of strings over a sounding-board. In one case it is played by the fingers, in the other by mallets. In Plate LXXII. it resembles a guitar.

Pseu'di-sod'o-mon. A style of masonry in which the face is formed of squared stones, the courses varying in hight, and the middle of the wall being filled in with smaller flat stones in courses. See MASONRY.

Pseu'do-dip'ter-al. (*Architecture.*) Having a single row of columns placed at a distance from the cell equal to twice their distance from each other.

Pseu'do-pe-rip'ter-al. (*Architecture.*) Having the side-columns attached to the walls instead of separated by an interval, as in peripteral.

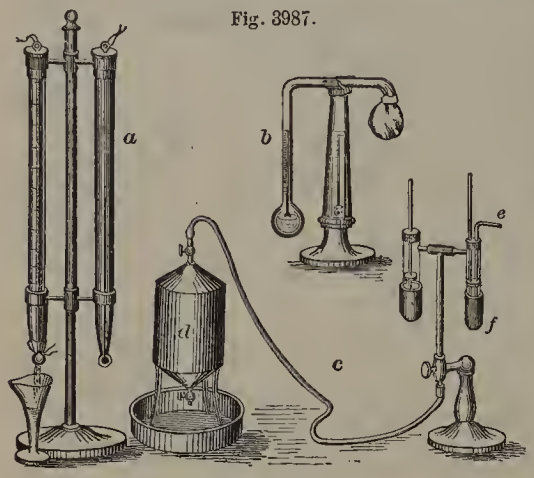
Pseu'do-scope. An optical instrument invented by Wheatstone for producing an apparent reversion of the relief of an object to which it is directed, by the transposition of the distances of the points which compose it. A false impression is thus conveyed to the eye, a globe becoming apparently concave and a hollow body assuming a convex form.

Psy-chrom'e-ter. A form of hygrometer invented by August. It is on the principle suggested by Hutton, and employed by Leslie in his differential thermometer. It has two very sensitive thermometers freely suspended to the same frame. Of the two bulbs, one is wrapped with linen rags and the other is free. The wrapped bulb is moistened and the evaporation is rapid in proportion to the hygrometric condition of the air. The evaporation reduces the temperature of the inclosed bulb and the mercury sinks. From the different indications of

the two thermometers the amount of moisture in the air is derived.

a is the kind known on the Continent of Europe as *August's psychrometer*, and in England as *Mason's hygrometer*. It has

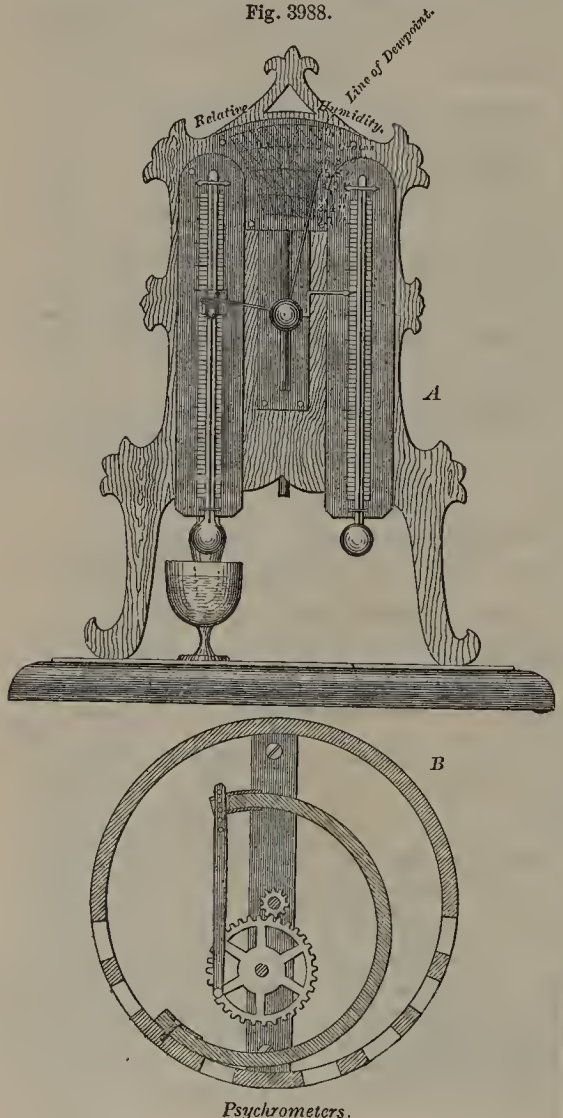
Fig. 3987.



Psychrometers.

a cotton-wick leading to water in a glass below the wet bulb. The air circulates freely around the wet bulb. This is now the accepted form of hygrometer, being more convenient than the

Fig. 3988.



Psychrometers.

Daniell's dew-point instrument. (See HYGROMETER.) This is shown at *b*. It consists of a bent tube with a globe at each end, and is partly filled with ether, the remainder of the space with vapor of ether, the air having been expelled. One of the tubes contains a thermometer whose bulb is in the liquid. The stem has another thermometer as a means of comparison. The upper globe being moistened externally with ether, evaporation takes place, producing condensation of ether in the upper bulb, which causes evaporation from the ether in the lower bulb, and consequent fall of temperature in the liquid. By watching the lower globe, the exact point at which dew commences to fall may be noticed, and the temperature of the inclosed thermometer is compared with that on the stem.

The precise temperature at which this moisture begins to form at the level of the surface of the ether is the *dew-point*, and the difference between the *dew-point* temperature and the natural temperature is the degree of dryness — *thermometric*.

By the use of tables prepared for the purpose, the degree *hygrometric* also may be ascertained, together with other conditions of the aqueous vapor; such as its elasticity, density, weight in a cubic foot of air, rate of evaporation.

c is Regnault's hygrometer; has a pair of glass-tubes closed at the ends by thin silver cups, containing ether; in these are thermometers whose stems rise through the corks which close the upper ends of the tubes. Air is drawn, by means of an aspirator *d*, through the tube *e*, and bubbles up through the ether in cup *f*, causing it to evaporate and lose sensible heat; the vapor passes with the air through the stem of the standard, and by the elastic tube to the aspirator. The moment of the deposition of dew is observed by means of a telescope so as to prevent vitiation of the result by the warmth of the body.

A (Fig. 3988) shows a form of instrument in which two indexes, that of the wet bulb and that of the dry one, are so combined that when one is placed at the hight of the mercury in a dry-bulb thermometer, and another at the hight of the mercury in a wet-bulb thermometer, a third point will indicate on a scale the proportion of moisture in the atmosphere.

The finger, whose position is a result of the two conditions stated, points on the diagram of lines, which is so constructed as to indicate the relative humidity by the upper arc of degrees, the dew-point by a diagonal range of figures, and the absolute moisture by a vertical column of figures.

B is a hygrometer in which a semicircular strip of wood, having the grain running transversely, has its convex side coated with water-tight cement. The free end of the strip is connected to a registering apparatus which indicates the humidity by the expansion of the exposed side of the strip.

Pter-yg'i-um. (*Surgical.*) A delicate pointed instrument for removing a membraneous excrescence from the internal canthus of the eye. The membrane expands on the albuginea and cornea, toward the pupil.

Pu-cel'las. (*Glass-making.*) A pair of tongs whose flat jaws rub upon the exterior surface of an object to reduce its diameter while it is being rotated as the *ponty* rests on the arms of the glass-maker's chair. *Procellas.*

Fig. 3989.

Pucellas.

Pu-cheux'. A sugar-boiler's copper ladle.

Pud'den-ing. (*Nautical.*) *a*. A thick wreath or grommet of matting or oakum tapering toward the ends, and used as a fender; on ropes or spars, to prevent chafing; or to act as preventers to the yards in case the slings are shot away; in the latter case called a *dolphin*.

b. A braid of yarns around the ring of an anchor when a hempen hawser is to be bent thereto.

Pud'die. (*Fabric.*) A kind of cloth.

Pud'ding-stone. A composite marble formed of pebbles united by calcareous cement. *Breccia* is a pudding-stone whose portions are all calcareous. Some pudding-stones have siliceous and aluminous portions. The cement of pudding-stone is softer and not susceptible of polish.

Pud'dle. 1. (*Hydraulic Engineering.*) Well-tempered clay and sand used to render banks or dikes impervious.

2. PISÉ-WORK (which see).

Pud'dled Steel. (*Metallurgy.*) Pig-iron is puddled in a reverberatory furnace, and the process is stopped on the instant that the carbon has been sufficiently eliminated. Reported to have been first made

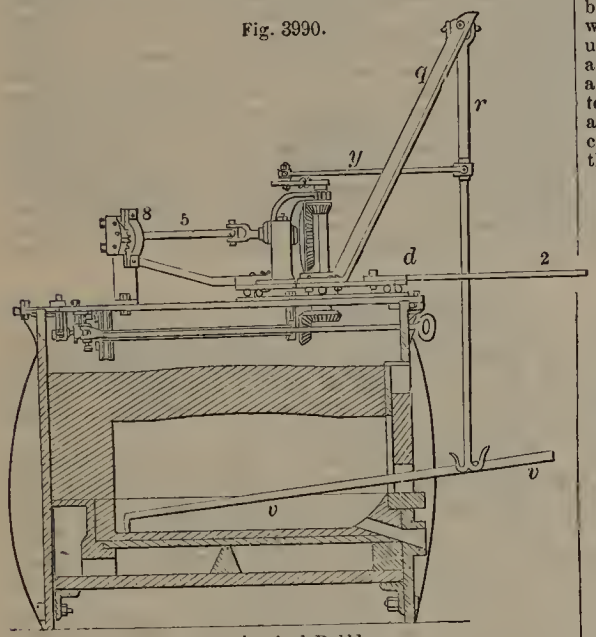
by Anton Lohage, of Westphalia. In 1848, he began his trials at the Haspe Iron Works, near Hagen, in Westphalia, and after some time he succeeded in producing steel of good and uniform quality by the ordinary puddling process. His invention was patented 1850, in England, by Ewald Riepe, and introduced at Low Moor; but, owing to the quality of the pig-iron, its use was very limited in England until, in 1858, Mr. William Clay introduced the process on a large scale at the Mersey Steel and Iron Works, Liverpool. In Germany, about 100,000 tons of puddled steel are made every year, and it forms the principal material for Krupp's celebrated cast-steel.

Pud'dler. Mechanical puddlers have assumed two forms.

1. The *Mechanical Rabble.* The rabble is worked back and forth through the stopper-hole in the door, as in the hand operation, except that motion is given by machinery outside. The rabble is worked in and out, and at the same time has a horizontal sweep so as to reach the various parts of the floor of the furnace.

The rabble *v* is suspended from the rod *r*, which is reciprocated by the pitman *y* and crank *x*. The point of suspension

Fig. 3990.



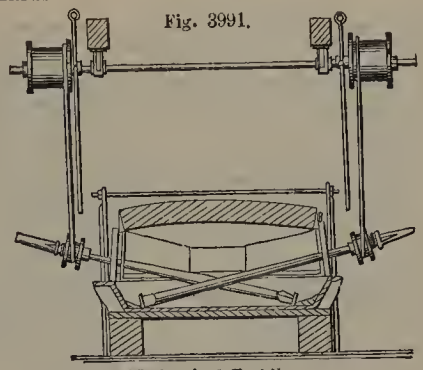
Mechanical Rabble.

of the rod *r* is at the head of a gib *q* which rises from a bed-plate *d* which is movable automatically in a horizontal plane, in an arc of a circle, so that a reciprocating motion is given to the point of suspension of the hanger *r*, which is communicated to the end of the rabble, causing the latter, instead of working backward and forward in the same line, to assume a new direction at each stroke, working successively over every portion of the floor of the furnace, within certain limits, in lines radiating from the working hole in the door of the furnace, corresponding exactly to the action in hand puddling. The movement of the hanger and rabble is controlled by means of a bow 2, proportioned in shape and dimensions to the character and extent of the furnace bottom. The in-and-out motion of the rabble is by means of bevel-gearing, while the reciprocating motion of the bed *d* which runs on balls is by means of a pinion on the end of the shaft 5 working in an endless rack 8.

When the iron begins to thicken, or, as it is termed, is *coming to nature*, the machinery is disconnected by knocking out the cotter that fixes the upper end of the vertical working arm; the arm then drops out, leaving the furnace door clear for the puddler to ball up the iron, which is done exactly in the same manner as in ordinary puddling-furnaces.

Fig 3991 is a mechanical puddler having a rotative motion by machinery, while the *rabble* is directed by the attendant to any part of the furnace. The tool-handle is hollow, and is used for injecting air, steam, or other gases into the molten iron during the puddling.

Fig. 3991.



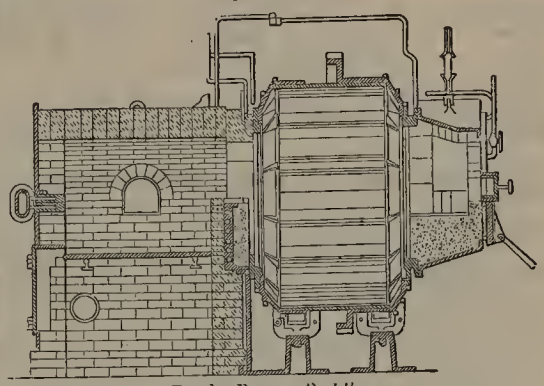
Mechanical Puddler.

2. The *rotary puddling-furnace.*

Many forms of rotary furnaces have been essayed, in which the charge is rolled around in a rotating barrel-shaped chamber.

The Danks puddling-furnace has an ordinary furnace grate, but, instead of the large chamber of the reverberatory metal-chamber, a barrel-shaped vessel receives the charge of pig-metal, and through this the flame passes to the chimney. The metal once melted, the barrel is caused to revolve by steam power, and as the fluid metal flows around the interior, the carbon which it contains and the accompanying silicon are oxidized by contact with the passing oxygen in the furnace gases, and with that of the iron ore with which the barrel is lined. Gradually it loses its fluidity, becomes viscous and finally spongy, and is then malleable iron. One end of the barrel is movable, and that being removed, the *ball* of spongy iron, weighing 600 to 700 pounds, is taken out, carried by tongs suspended from an overhead railroad to the squeezers, where it is rolled and compressed into a billet of quite compact iron, and thence to the *muck train* of rolls, in which it is given the shape of a long

Fig. 3992



Danks Rotary Puddler.

rough-looking bar, which only requires additional rolling to convert it into *merchant bar.*

The foundation for the lining of the cylinder consists of a mixture of pulverized iron ore and pure lime, worked with water into the consisteucy of a thick paste. Upon the completion of the initial lining, a quantity of pulverized iron ore, about one fifth of the total amount required to fettle the apparatus, is thrown in, the furnace is heated and made to revolve slowly until the iron is found to be completely melted, and the apparatus is then stopped. That part of the molten iron which has not been consumed by glazing the initial lining surface runs to the lowest level of the furnace, and there forms a pool, into which there are put a number of small and large lumps of iron ore. This part of the fettling is allowed to set, when a fresh quantity of pulverized ore is thrown in. The furnace is again made to rotate slightly until the newly added ore is liquefied, when the apparatus is again stopped, and the pool is filled with lumps as before. The operation is continued in this way until the whole of the vessel is properly fettled. From 2 to 2½ tons of iron ore are required to fettle a 700-lb. furnace.

The iron is charged into the furnace either in a solid or molten condition. When charged in the shape of pig-iron, the melting down occupies from thirty to thirty-five minutes, during which a partial rotation is given to the furnace from time to time in order to expose equally all sides of the charge to the flame. When the whole of this is thoroughly melted, the furnace is made to rotate once or twice per minute only during the first five or ten minutes, in order to obtain the most perfect action of the cinder upon the molten iron. A stream of water

is injected through a stopper-hole along and just above the line of contact between the floating cinder and the inner surface of the vessel on the descending side. A certain portion of uncontaminated cinder is thereby solidified on the metal surface, and is carried down into or below the bath of molten iron in a continuous stream, which, in rising up through the iron, combines with the impurities of the latter. On the expiration of the five or ten minutes, the iron begins to thicken, and the motion is stopped. The heat is then raised so that the cinder shall be perfectly liquefied, and the vessel is brought into such a position that the tap-hole shall be just over the level of the iron, which by this time has become partly pasty. The cinder is then run off The heat is again raised, and the furnace is put in motion at a velocity of from six to eight revolutions per minute, by which means the charge is dashed about violently in the furnace. A high temperature being kept up and the charge being continually turned over, the particles begin to adhere, when the velocity of the apparatus is lowered to from two to three revolutions per minute, upon which the ball then very speedily forms. The puddler then solidifies the front end of the ball by a few blows from a tool applied through the stopper-holes, and it is withdrawn through the end — opened by the removal of the head and the moving out of the way of the flue — of the chamber.

A large fork, suspended from a crane, is put into the vessel along one side, and the ball, which by a turn of the vessel is rolled on to the fork, is then taken out by means of the crane. The ball is then worked in a squeezer. The flue is replaced after the requisite quantities of cinder and metal have been again charged, and the process is continued. From eight to ten charges are made before any refettling is required, and these heats are worked in a day of ten hours. See PUDDLING-FURNACE.

Mechanical Puddlers.

Griffith	1865	Gove	1858
McCarty	1352	Dormoy	1869
Berard	1867	Riley	1873
Harrison	1864	Danes	1873
Bloomhall	1872	Sellers	1873
Bennett	1864	Wood	1870
Heatley	1873	Heatley	1869

Revolving Puddlers.

Beadlestone	Dec. 9, 1857	Danks	Nov. 24, 1868
Heaton	Aug. 13, 1867	Danks	Oct. 20, 1869
Allen	Apr. 14, 1868	Yates	Feb. 23, 1869
Yates	Feb. 23, 1869		

See also patents to Boynton, Allen, Jenkins, Smith, 1871; Jackson, Goodrich, Richardson, *et al.*, Davies, Post, 1872; Jones, Danks, 1873.

Pud'dle-rolls. The first, or *roughing, rolls* of a rolling-mill. Invented by Henry Cort, England, and patented in 1783.

The loop, or ball of puddled iron, after a preliminary forging, is drawn out by passing through the puddle-rolls, instead of being extended under the hammer. It is then a rough bar.

The rolls which bring the iron to definite merchantable shape are known as the *merchant train.*

The process of drawing the loops in grooved rolls was suggested in Payne's patent (England, 1728), but does not seem to have been practiced.

Pud'dling. 1. (*Metallurgy.*) *a.* The lining of the hearth or boshes of a furnace in which metal is melted.

The material of the *puddle* was formerly, for some uses, of clay and charcoal worked into a plastic condition.

The term *puddling* has arisen from the fact that the hearth was originally made by a *puddling* of clay upon the bricks or masonry of the furnace. The clay is now superseded by a *fixing* of ore, cinder, and scrap, which is banked up around the boshes to protect them from the heat. It is known as *fettling* in some parts of England. See FIXING.

b. The process of converting cast into wrought iron by boiling and stirring in connection with the decarbonizing action of the atmosphere which passes through the furnace. Contact between the metal and solid fuel is thereby avoided.

The process was invented and brought into extensive use by Henry Cort, and patented in 1784.

Cort also invented the *puddle-rolls,* by which the bloom resulting from a preliminary forging of the loop is drawn out into bars, instead of being extended under the hammer; this Cort patented in 1783.

In each case Cort does not seem to have been the first inventor, though he was the most successful and meritorious. He was ruined by the chicanery of partners and government officials, and died poor. Several acts of Parliament, and government grants of small amount, were made to his descendants, even as late as 1856.

The puddle-rolls patented by Cort in 1783 are described in Payne's patent, 1728.

The process of puddling iron in a reverberating furnace, stirring, gathering the loop, hammering, and rolling, is described in the specification of the Brothers Cranage, 1766, and the furnace in Onion's patent, 1783.

The pig-iron, broken into pieces and mixed with a certain proportion of *hammer-slag*, is put into the furnace, and in the course of 35 or 40 minutes is melted. During this time it has to be constantly stirred with the *rabble;* the pieces, as they soften, being broken finer, until at last the mass melts and passes to the boiling stage. At this point the severer part of the puddler's work commences. The rabble must be quickly and violently moved throughout the whole charge to promote ebullition. After a while the metal gets thick or pasty, and offers greater resistance to the tool, which is worked from side to side of the furnace, to separate the tough mass into portions. This stage is called *coming to nature*, and is that in which the pig, deprived for the most part of its silicon and carbon, passes to a purer form, as wrought-iron, requiring only compression to expel the slag and consolidate its particles, and rolling or hammering into merchantable shape, to fit it for use or market. Preparatory to these last-indicated operations, the *balls*, into which the puddler has separated the pasty mass, are taken out and subjected to the hammer or squeezer, which condenses them into blooms that pass to the rolling-mill. The whole time occupied in the puddling is about an hour and a half. See PUDDLING-FURNACE.

2. (*Hydraulic Engineering.*) Working plastic clay behind sheet-piling, in a coffer-dam, a wall in a dike, the lining for a canal, or in other situation, to resist the penetration of water; generally as supplementary to a main structure and forming a retentive stratum or clothing therefor.

Pud'dling-fur'nace. (*Metallurgy.*) One in which pig-iron, broken into pieces and mixed with *hammer-slag*, cinder, ore, according to circumstances, is melted and continuously stirred for a considerable time while boiling, in order to expose it thoroughly to the action of the current of air passing through the furnace, so as to effect the chemical changes required for the separation and removal of the impurities originally combined with the iron. The metal has then to be balled up into separate masses of about one hundred and twenty pounds each for the shingling hammer; and the whole process extends over about an hour, from the time of melting the pig-iron for each heat, of which six are worked in the day.

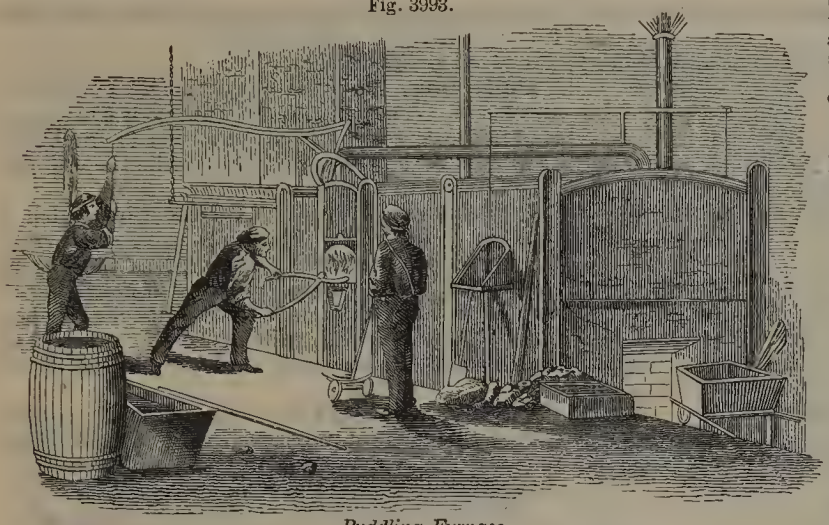
The process involves very laborious and long-continued hand-labor, and the current of air passing through the furnace has to be regulated and changed as the process advances.

Fig. 3993 gives an idea of the general appearance of the exterior of the furnace. The furnace-door is by the man in the foreground, who is holding the handle of the *ball-trolley* to catch the *ball* or *loup*, which the furnace-man is just taking out of the iron chamber. A third man lifts the door by means of the lever.

Fig. 3994 shows a puddling-furnace of usual construction. The furnace-door is at *L*; *D*, the door of the iron-chamber; *K*, the neck; *M*, the stack. The iron boshes stand on pillars, and their exteriors are cooled by water introduced by tubes. The *stack M* also stands on pillars, so that it is not affected by the tearing down of the *neck*

Fig. 3995 shows two forms of puddling-furnaces; a single-chambered and a double chambered furnace.

Fig. 3993.



Puddling-Furnace.

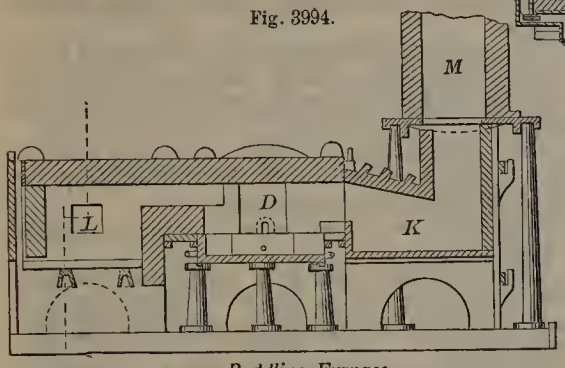
In Fig. 3995, *A*,—

a, fire-chamber.
b, iron-chamber.
c, hearth.
d, stock-hole.
e, throat.
f, neck.
g, bridge.
h, stack.
i, velvet-tree.
k, grate.
l, roof.
m, tap-hole.
n, stopper-hole.

In Fig. 3995, *B*,—

a, first fire-chamber.
a', second fire-chamber.
b, metal-chamber.
c, bridge.
d, water-back.
f, pipe to supply water-boshes *g*.

Fig. 3994.



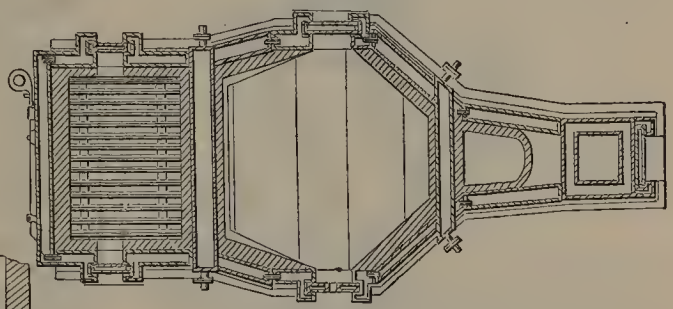
Puddling-Furnace.

Fig. 3996 shows the plan-view of the fire-chamber, iron-chamber, neck, and stack. The water-jacket is open above, giving free exit to steam, and the separate sections are connected by tubular bolts, allowing passage of water. The bridges contain water, and have ascending and descending steam and water pipes.

The puddling-furnace was invented by an iron-master of the name of Henry Cort, about the year 1780, the bed of whose furnace was made of sand, consequently the carburet was refined, many of its impurities, especially the carbon, which is the metalloid causing fluidity, was driven from it; hence, when the pig-iron was melted, it assumed the form of grain. Mr. Samuel Baldwin Rogers introduced the present system of iron bottoms to furnaces, which obviated the deteriorating influence of the silicon due to the sandy bed of the Cort furnace, and eventually did away with the finery process.

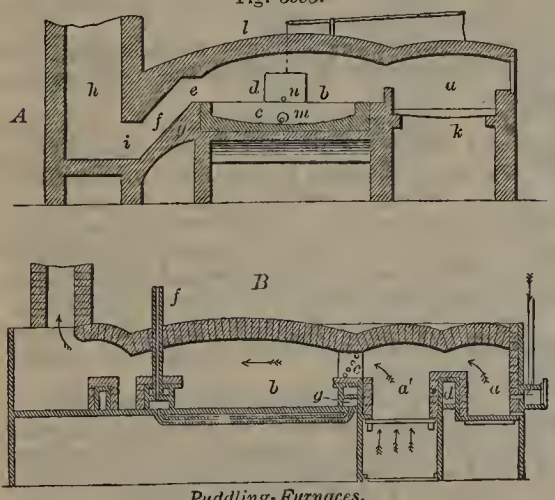
The chamber the pig-metal is charged with consists of iron plates forming the bottom and sides, which are lined with refractory slags rich in oxides of iron. In changing the heat, slags and scales from the hammers and rollers are thrown on the hearth or bottom, and on this the charge of pig-metal, consisting of 510 pounds to 540 pounds. Fuel is then thrown into the grate, and in about twenty-five or forty minutes this carburet of iron becomes liquid, and assumes the form of a molten plate of iron some one and a half to two inches thick Being heavier than the slags, the latter pass through it, and rise to the top. In passing, the oxygen contained in the silicates combines with the carbon of the iron, and decarbonizes it; but unless the iron is agitated it will not become malleable. Hence the puddler, with a bar called the *rabble*, agitates the metal, and brings in contact the oxygen of the silicate with the carbon and other impurities of the iron. As the carbon is leaving the metal, its atoms expand and become of less specific gravity, and it throws off carbonic oxide gas, the blue flame of which is plainly seen by any one who watches the process. The puddler, at this stage, must be incessant in his operation, for the transformation scene is coming, and the crude iron is becoming malleable. The boiling of the mass is kept up by the fresh energy of the puddler until, as the carbon diminishes, the atoms of the iron begin to knit or agglutinate together in a soft spongy consistency, the *cinder* taking the place of the once molten iron. The iron is now as sensitive to oxygen as a tropical plant would be if placed in a temperature at zero, and as the human lungs would be if inhaling pure oxygen; it lives, as it were, too fast It is at this point that smoke-preventers are puzzled; but a deoxidizing flame is kept on the iron while it is being kneaded and divided into balls, preparatory to being brought out of the furnace; and, when done, the lump is taken to the hammer and beaten into the required shape for rolling it into the puddled bar of commerce. This operation is called *shingling*.

Fig. 3996.



Plan of Puddling-Furnace.

Fig. 3995.



Puddling-Furnaces.

Pud'dling-ma-chine'. A mechanical puddler. It operates by means of mechanical rabbles, or by rotation of the furnace. See PUDDLER.

Puff'er. A vat in which goods are boiled in an alkaline solution. See BUCKING-KIER.

Puff'er-pipe. The vertical axial pipe in a kier in which cotton goods are washed during the bleaching process. See KIER.

Pug. (*Pottery.*) The mill in which *slip* is kneaded and from which it comes in the form of bricks. These are stored in cellars to *ripen*. See PUG-MILL.

Pug'ging. 1. (*Building.*) *a.* Lining the spaces

between floor-joists with coarse mortar to prevent the passage of sound.

b. Stuff laid on partition-walls to deaden sound; felt, saw-dust, tan-bark. *Deadening.*

2. *Claying;* tamping with clay; stopping with *puddle.*

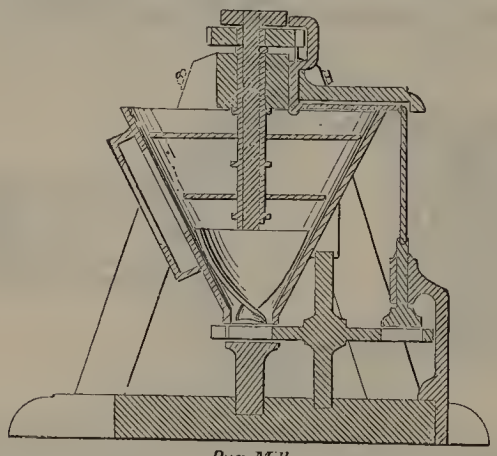
3. Grinding of clay, with a sufficiency of water to render it plastic. *Tempering.*

Pug-mill. A mill by which clay is worked, to blend its materials and render it plastic, for bricks or pottery.

It has an upright cylinder armed with intruding blades, and an upright revolving axis armed with radial blades which work in the intervals of the former. Having a spiral arrangement or oblique position, the tendency of the blades is to force the clay constantly downward to the exit.

Fig. 3997 shows a mill in which the clay is cut into pieces by the knives, and then ground and tempered, being eventually

Fig. 3997.



Pug-Mill.

pressed out at the lower end by the spiral blade which discharges it into the brick molds beneath.

Pug-tub. (*Metallurgy.*) A cistern in which argentiferous slimes are stirred up with water in order to remove some of the mud which becomes suspended in the water.

Pu'las. A twine made by the Malays from a species of nettle.

Pull. 1. The lever of a beer-engine or counter-pump. It is vertical when at rest, and is *pulled* down to actuate the piston in the pump-cylinder.

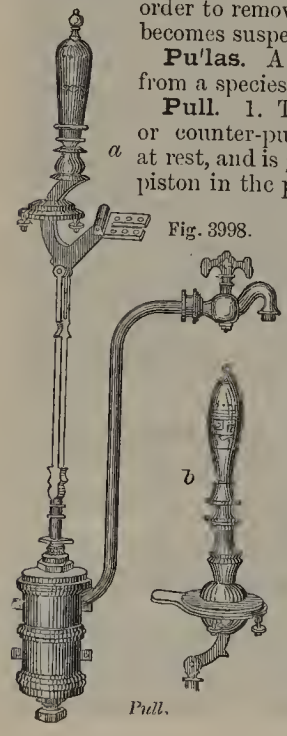


Fig. 3998.

Pull.

a shows a *quadrant-pull;* being pulled to the right, the arc-shaped piece travels in its guide, lifting the pump-rod and ejecting the beer at the faucet.

b is a *sphere-pull,* the ball rolling in its socket as the lever is drawn over to the right.

2. The knob and stem of a door-bell or door-gong.

3. A catch or lip upon a drawer or door by which it is pulled open.

4. (*Printing.*) *a.* The space on the form which was impressed by the platen, in the old style of printing-press, where two impressions were sometimes required for a large form.

b. A single impression.

Pull-cock. A faucet whose spigot or movable member is vertical while the passage is closed, and is pulled over to a horizontal position to discharge. It rotates 90° in a vertical plane, while the ordinary spigot moves in a horizontal plane.

Pull-down. (*Music.*) A brass wire which is attached to the under side of the valve of an organ and by which the valve is operated as the key of the manual is depressed; the *pull-down* passes through a perforation in a brass plate on the bottom of the wind-chest, and connects by a lever and a small rod called a *sticker* with the rear end of the key.

Pul'ley. A wheel with a grooved, flat, or slightly convex rim, adapted to receive a cord or band, which runs over it. Its function is to transmit power or change the direction of motion.

It is said to have been invented by Archytas of Tarentum, a disciple of Pythagoras, about 516 B. C. It does not appear to have been used by the ancient Egyptians.

The combination of pulleys is ascribed to Archimedes, who died 212 B. C.

Vitruvius described the pulley. He refers to the sheaves (*orbiculi*) in the blocks (*trochlea*), and defines the system by the aggregate number of sheaves in the two blocks, — *trispastos, pentaspastos,* etc.

We read of pulleys on the great ship built by Archimedes for Dionysius of Syracuse, about 250 B. C. They were used for hoisting stones into the towers for the supply of the catapults and other engines.

The cord and pulley principle is employed in the tendons of animals, some of which have their directions changed by passing over fixed pulleys of cartilage.

One of the muscles by which the eyeball is moved is called the *trochlearis,* from the *trochlea* or pulley through which the tendon passes.

The pulley is classed as one of the mechanical powers.

Pulleys without blocks or carriers are properly *sheaves* or *pulley-wheels,* which are mounted in various ways, according to the purpose for which they are designed.

The simplest form is that of a wheel with a nearly flat face (*a*), over which a band passes. This is the common machine-pulley used on shafting, which is ordinarily supported by hangers from the ceiling of the shop. Couplings and hangers are described under those separate heads. Pulleys to be mounted on machine-shop shafting are: —

Fast; being firmly attached to their shaft, from which they receive, or to which they communicate, motion.

Loose; running free on the shaft, to receive the belt and allow it still to traverse without being affected by, or affecting the motion of, the shafting.

Speed; having a number of faces or grooves of different diameter (*b*), so as to communicate varying speeds with a given rate of motion of the belt or cord. This is common in lathes and analogous machines, and is sometimes called a *cone*-pulley.

Conical; used in cotton machinery, etc., where a gradually increasing or decreasing speed is required. See CONE-PULLEY.

The ordinary single-sheave pulley transmits and changes the direction of motion without increasing the power. The most familiar form of mounting is that used on shipboard (*d*), in which the sheave runs on a pintle in a block which is embraced by a *strap*

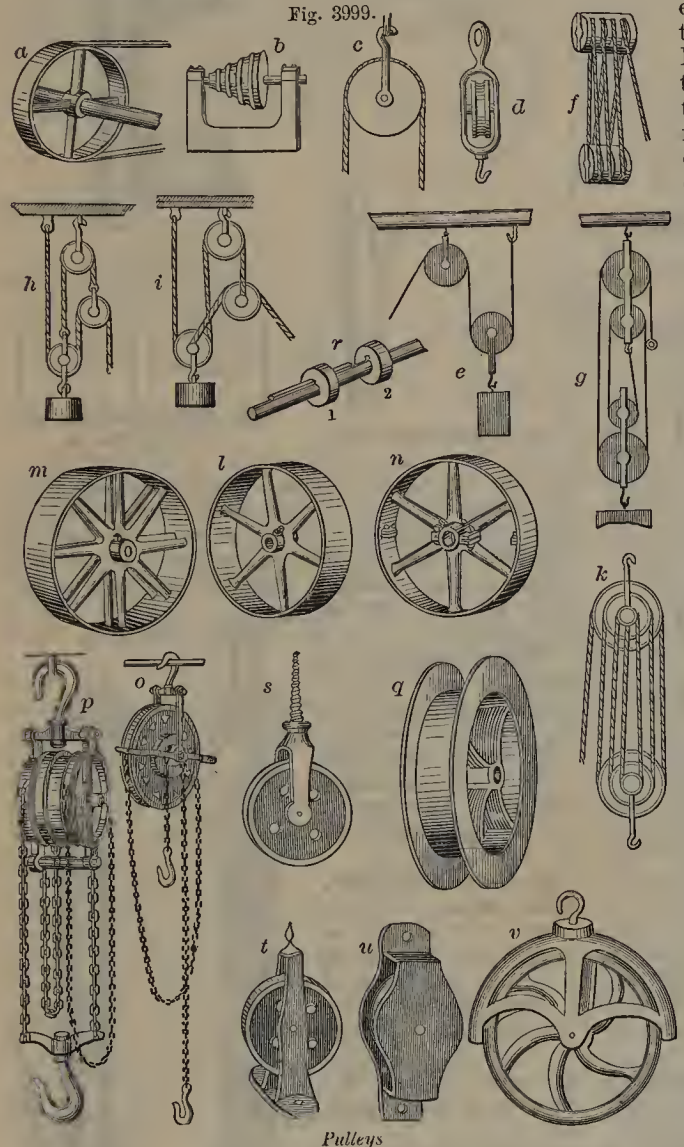
of metal or rope having an eye at one end and a hook at the other. See BLOCK.

Another form of mounting a single sheave is a simple hanger (*c*); this is not so common in regular hoisting-tackle, but is familiar in models and experimental machines. Having no *cheeks*, the line may get out of its groove and cease to *run*.

In compound systems of pulleys, the sheaves of each block are usually arranged upon the same through pin, which passes through each cheek and the walls of separation between the sheaves.

In another method, the sheaves turn in slots arranged in vertical series in a *long-tackle block*, instead of horizontally. The sizes of the sheaves vary, so

Fig. 3999.



Pulleys

that the respective ropes do not run in contact, and thus rub against each other.

Compound pulleys and combinations of pulleys are used for gaining power with a corresponding loss of speed. The arrangements are various.

e. The rope runs over sheaves in a *standing* pulley and a *running* pulley. The gain in power is two-fold. (Friction will not be considered in this and the following estimates, though this causes a considerable loss of power under even the most favorable circumstances, increasing with the number of sheaves.)

The *block* and *tackle* or *fall* and *tackle*, as it is variously called, has a pair of pulleys in which several sheaves are arranged to run on the same pintle in the block (*f*), or one above the other (*g*). The effect is the same, as each sheave runs independently on its own pintle at such a rate as it is impelled by the rope. The power is thus calculated: Divide the weight by double the number of sheaves in the lower block; the quotient is the power required to balance the weight.

In systems of pulleys with one rope and one movable block, the load is as many times the power as there are different parts of the rope engaged in supporting the movable block.

The tension on each part of the rope is equal to the power; or, in other words, has the same tension throughout its length. Each portion of the rope connecting the two pulleys is adequate to the support of the power, which is 1, and, the strands connecting the pulleys being 6, the statement of the power to the load is 1 to 6, in the example shown; the rope traveling 6 feet for every foot gained in the raising of the lower block and its load.

The Spanish Barton (*h i*) has two cords and two running blocks and one standing block. See BARTON.

Pulleys are susceptible of many other combinations, by increasing the number and varying the points of attachment to the load or to the support. See Brown's "507 Mechanical Movements." See TACKLE.

In White's pulleys (*k*) the diameter of each sheave is proportioned to its rate of revolution, so that all may revolve in the same time. All the sheaves turn on the same pin, and each may constitute an independently revolving pulley, or they all may be cut on the face of a solid conical block after the manner of speed-pulleys. In an arrangement of this kind, in which the theoretical power is to the weight as 1 to 6, the diameters of the set on one block would be 1, 3, 5, and of those on the other 2, 4, 6. The rule above stated for estimating the relations of the power and load may be stated in another form.

Pulleys for driving machinery by means of flat belting are usually made somewhat swelling on their peripheries. It is found by experience that the band when in motion has a tendency to work up toward the highest part of the face of the pulley, so that it is kept more centrally to its work when this form is adopted. Grooved pulleys are used for ropes or circular bands, and for some purposes flat-faced pulleys having a circumferential ledge at each side are employed (*q*).

l is a *plain* or ordinary machine-pulley; *m*, a *double-arm* pulley, by which means additional stiffness is imparted to the rim; *n* is a *split* or divided rim pulley; the halves are bolted together by flanges on the hub and interior of the rim. *o p* are differential pulleys for hoisting. The *flat-rope* pulley (*q*) is used, as its name indicates, for transmitting power in some cases by means of a band or flat rope. *r* is a lock-pulley. In this arrangement, the spline which secures the fast pulley 1 to the shaft is fitted somewhat loosely, so that it may be pushed forward to engage with a hole in a loose pulley 2, and withdrawn therefrom, compelling it to revolve with the pulley or allowing it to stand loose on the shaft.

Pulleys for household hardware have specific names derived from their modes of attachment.

s, screw-pulley.
t, frame-pulley.
u, side pulley.
v, well-pulley for dumb-waiters, etc.

Specific names are given to pulleys, according to place, purpose, material, construction. See —

Anti-friction pulley.
Bartou.
Belting.
Block (varieties, see BLOCK)
Block and tackle.
Bull's eye.
Chain-pulley.
Click-pulley.
Clutch-pulley.
Cone-pulley.
Conical pulley.
Differential pulley.
Double-speed pulley.
Expanding pulley.
Expansion-drum.
Fall and tackle.
Fast and loose pulley.
Fast pulley.
Flat-rope pulley.
Friction-clutch pulley.
Friction-pulley.
Guide-pulley.
Idler.
Lock-pulley.
Loose pulley.
Pulley-block.
Pulley clutch or tongs.
Pulley-sheave.
Pulley-stand.
Pulley suspension-hook.
Pulley-wheel.
Rigger.
Runner.
Sash-pulley.
Scored pulley-sheave.
Sliding-pulley.
Snatch-block.
Speed-pulley.
Tackle.
Taglia.
Tension-pulley.
Tightening-pulley.
Traversing-pulley.
Two-speed pulley.
Variable-speed pulley.
Whip.
Whip and runner.
Whip-on-whip.

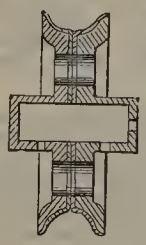
Pul'ley-block. A shell with a sheave or sheaves. See PULLEY.

Fig. 4001 is a skeleton frame with an iron sheave,

Fig. 4000.

Pulley-Block.

Fig 4001.



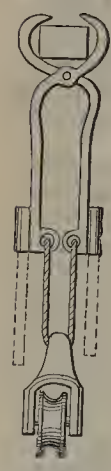
Iron Pulley-Block.

cast in two pieces and with hollow axis. The sheave is shown on an enlarged scale on the left.

Pul'ley-box. (*Loom.*) A frame containing the pulleys for guiding the tail-cords in a draw-loom.

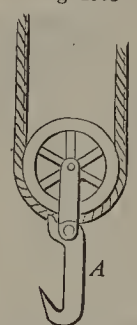
Pul'ley-check. An automatic device by which the rope is kept from running back over a pulley. In Fig. 4003, the upper branch of hook *A*, pivoted to an arm hanging loosely from the axis of the pulley, allows the rope to move freely in one direction, but prevents movement in the opposite direction when a weight is suspended from the lower part.

Fig. 4002.



Pulley-Clutch.

Fig. 4003.



Pulley-Check.

Pul'ley-clutch. A device for fastening a hoisting pulley to a beam or rafter. The grapple is adapted to hold automatically to a beam above, and has at the lower end of its arms eyes to receive the supporting rope of a pulley and sockets to receive handles to unclasp and adjust it.

Pul'ley-drum. The block inclosing the sheave.

Pul'ley-mor'tised. (*Carpentry.*) A mode of securing a ceiling-joist to a binding-joist so that their lower surfaces shall be flush. The end of the ceiling-joist has a tenon which lets into a mortise in the binding-joist.

Pul'ley-sheave. The roller with a grooved surface over which a rope runs in a block. To avoid the friction of the pulley-sheave *b* on its pin, an annular system of anti-friction rollers has been interposed between the inner bearing surface of the sheave and

Fig. 4004.

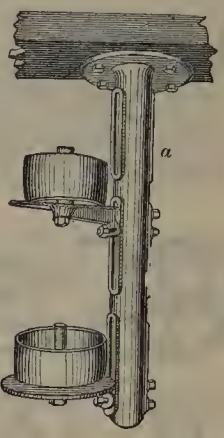
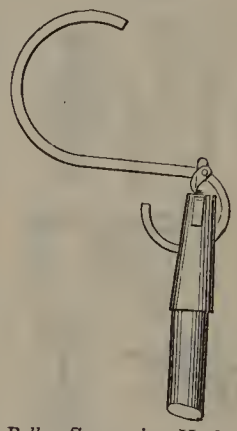
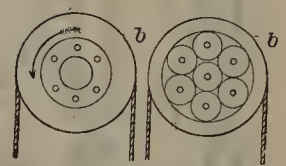


Fig. 4005.



Pulley Suspension Hook.



Mule Pulley-Stand and Anti-Friction Sheaves.

the pin on which it rotates. Each of the intervening rollers has an axial pin at each end, journaling into a ring which is at liberty to travel around the common axis. The rings keep the rollers at their proper relative distances, and prevent their becoming jammed against each other.

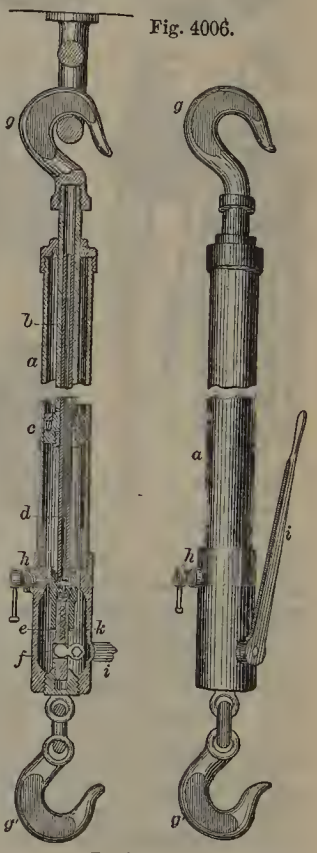
Pul'ley-stand. A hanger *a* on which the pulleys are adjustable in hight and angle of axis, so as to make them suit the belting, which may reach them at angles varying with the stem of the hanger.

Pul'ley Sus-pen'sion-hook. One to catch above a rafter or beam of a barn to afford a hold for the block of a hay-elevating fork. The socket is mounted on the end of a pole, the stop holding the hook in inclined position ready to slip over the rafter; the pole is then withdrawn from the socket.

Pul'ley-wheel. This is more properly termed a *sheave*. It is a wheel running on a pintle in a block and grooved on its periphery for the reception of a rope. See PULLEY.

Pull'ing-jack. A hydraulic device for lifting

Fig. 4006.



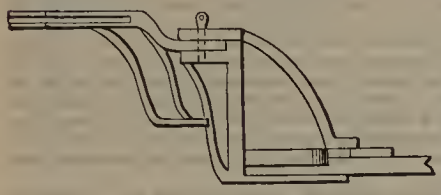
Pulling-Jack.

ing or pulling heavy weights. It consists of a cylinder *a* containing a tube *b* pivoted with a piston *c*, and having a second, interior tube *d* passing into the foot of the pump *e*, which projects into the reservoir *f*. In operation, one of the hooks *g g'* is attached to some fixed object, and the other to the weight to be moved; the water is introduced into the cistern, and the communicating valve between it and the interior tube *d* is closed by turning the screw *h*; working the lever *i* operates the plunger *k*, causing water to pass through the tube *d* from the cistern to the upper part of the cylinder *a*, into which it is discharged through apertures in the tubes *b d*, forcing the piston downward and lifting or drawing the object to which the hook *g'* is attached a distance equal to the movement of the piston. By unscrewing the valve *h* the water is again returned to the cistern *f* as the weight is lowered.

The view shows section and elevation.

Pull-i'ron. The piece at the hind end of the tongue of a street-car by which it is attached to the car.

Fig. 4007.



Pull-Iron.

Pull'man-car. (*Railway Engineering.*) A first-class car, usually fitted with capacious seats by day and with couches and berths by night. Named from the promoter of the enterprise and one of the inventors of the contrivances now used by the company.

The Pullman cars are owned by a company which puts them on the various railways of the country, carrying passengers who have first-class tickets and who pay extra for the use of the superior accommodation of the Pullman car. It is fast becoming the equivalent of the European "first-class," being superior in its fittings to the other cars of the train, and is more select and safe. See SLEEPING-CAR.

Pul'lock. See PUT-LOG.

Pull-piece. (*Horology.*) The wire or string attached to the striking mechanism by pulling which the clock is made to strike, for the purpose of bringing the striking and going mechanism into accordance or repeating the hour previously struck.

Pull-to. (*Weaving.*) The upper bar of the *lay*, *lathe*, or *batten*, which is used to beat up the weft. Also called the *lay-cap*.

Pul-mom'e-ter. An instrument for measuring the capacity of the lungs. A *pneumatometer*. See SPIROMETER.

Pull-o'ver. (*Hat-making.*) A conical cap of felted fur, forming a napping to be pulled over a hat-body. The napping is made upon a triangular piece of paper or metal, sometimes called a *bason*, the fur extending over both sides of the paper, which prevents the sides from uniting.

The term *pull-over* refers to the mode of fitting it to the body, in contradistinction to the mode of applying the napping by lapping it around the body, one side at a time.

Pulp. (*Paper-making.*) Paper-making material cut fine and suspended in water ready for manufacturing into paper.

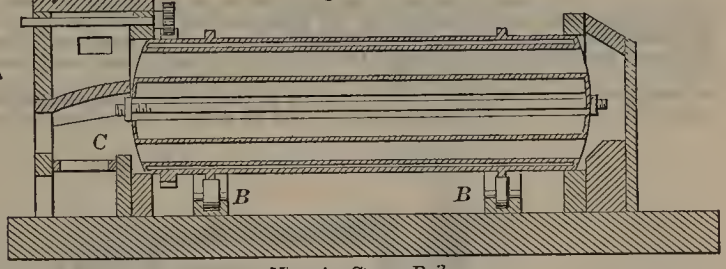
There are but few vegetable fibers collectible in any quantity which have not been tried for paper-making. A list of the more prominent is given under the head of PAPER (which see). For the machinery by which the fiber is reduced, see RAG-ENGINE.

Pulp-boil'er. An apparatus for treating paper stock, especially ground wood or cut straw, to remove gum, silex, starch, etc., from the fiber. See next article.

Pulp-di-gest'er. (*Paper-making.*) A machine for boiling stock for paper, such as wood, straw, and other material, to remove the amylaceous, glutinous, and siliceous matters, and obtain the fiber comparatively pure. The usual course is to boil the stock in an alkaline solution. The manufacture of paper from wood, straw, and various plants has been practiced for over a century, and reference is made under PAPER to three works of the last century whose leaves were made of various vegetable fibers other than cotton or linen. A list of several hundred plants which have been used or whose use has been suggested is given in the same article. See pages 1607–8.

Fig. 4008 shows an apparatus with a horizontal rotary tubular boiler having a fire-chamber *C* at one end, and a smoke-chamber at the other end. The fire-chamber has a roof, over which is a chamber communicating with a chimney. The heat passes through the tubes in the boiler below the level of the roof, and into the above-mentioned chamber, and then passes through those above said roof, into the chamber, and then into the chimney. The boiler rotates on bearing rollers *B*, and is moved by a pinion and annular gear.

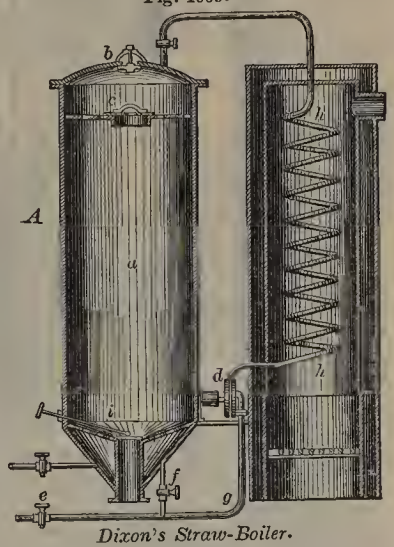
Fig. 4008.



Nixon's Straw-Boiler.

A (Fig. 4009) represents Dixon's straw-boiler. Rye-straw is chopped into lengths of about ¾ of an inch, cleansed, dusted, and passed through a heavy pair of iron rollers to open out the tubes and knots, after which it is transferred to the boiler *a*; this is partially filled with a solution of caustic soda in the proportion of 60 gallons to each 100 pounds of straw. The manhole cover *b* and diaphragm cover *c* are removed, and the straw and caustic solution alternately introduced; the latter is drawn from a tank by a rotary pump *d*, and when the boiler is filled the supply is cut off. The caustic alkali percolates through the straw, collects at the bottom of the boiler, and is drawn therefrom by the rotary pump, through the pipes *f g*, returning through the heated coil *h* to the upper part of the boiler, to be again passed through the straw. The boiling being finished, the straw is removed by withdrawing the slide valve *i*, provided with an exterior handle.

Fig. 4009.

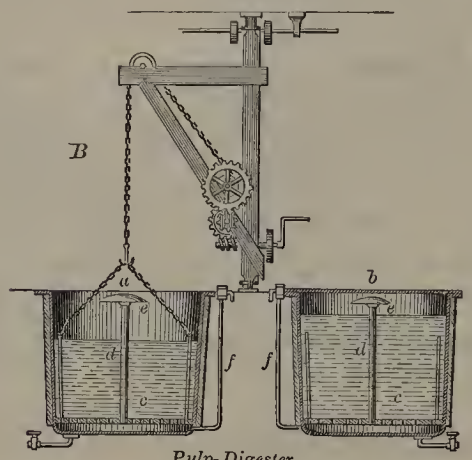


Dixon's Straw-Boiler.

B is an apparatus for boiling paper stock. It has a crank for

removing it from the tubs after boiling. *a* and *b* represent the boiling-tubs; these have perforated false bottoms *c c*, carrying upright pipes *d d* surmounted by the bonnets *e e*; steam is admitted through the pipes *f f* and distributed throughout the mass in the boiler by means of apertures in the perforated false bottom. The tubs are ½ or ¼ filled with a solution of

Fig. 4010.

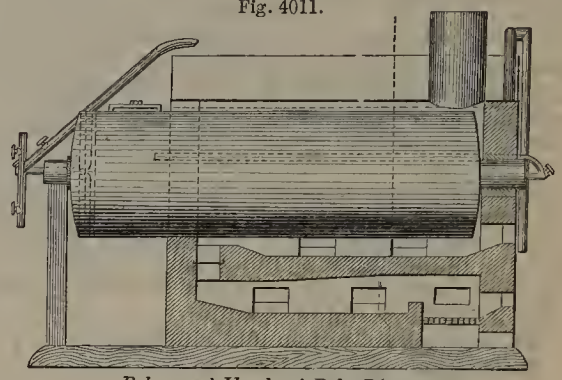


Pulp-Digester.

soda; steam is then turned on until the liquid boils, rising through the pipes *f f*, and is deflected by the under surface of the bonnet; the paper scraps are then gradually thrown in and distributed as uniformly as possible. After boiling, the mass is hoisted out of the tub by chains which are hooked to a frame connected with the false bottom and attached to the lifting chain of the crane. The tubs have covers of wood or metal to prevent escape of heat and steam. The liquid is drawn off by the pipes below.

Fig. 4011 is a view of the Palser and Howland rotary pulp-digester. It has a rotary boiler with a hollow trunnion through which passes a pipe having an internal partition, so that the

Fig. 4011.



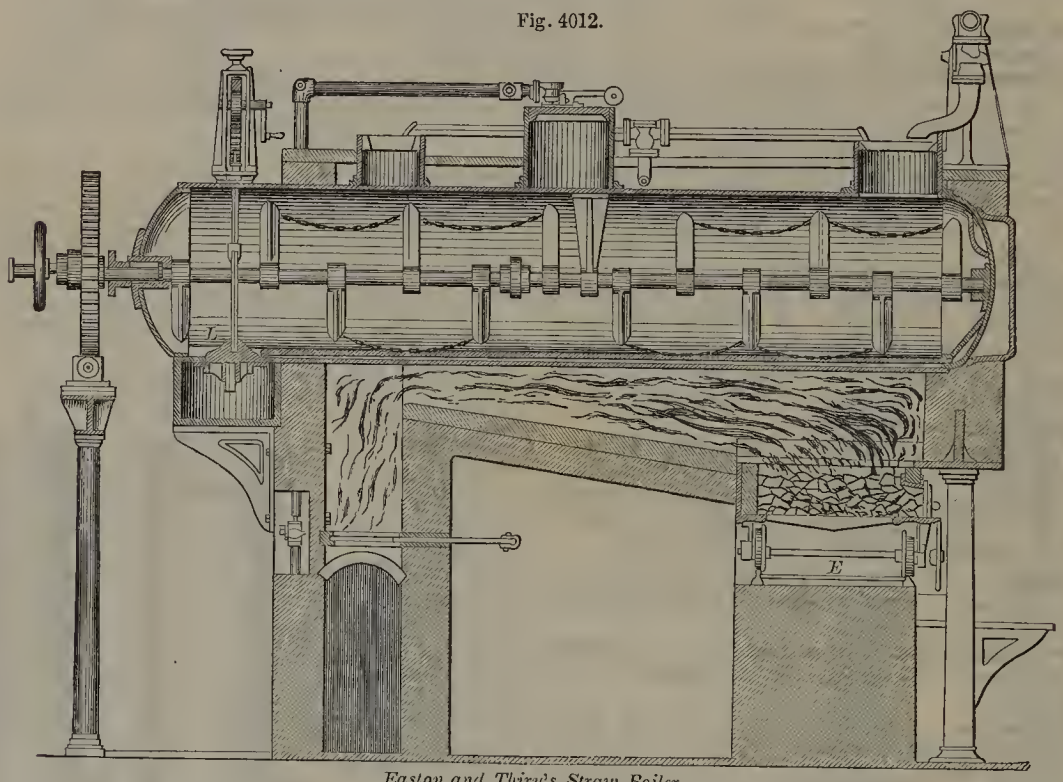
Palser and Howland Pulp-Digester.

steam from the upper portion of the boiler may find exit through one compartment of the pipe, and the liquid contents of the boiler may find an exit through the other compartment.

A perforated diaphragm near the end of the boiler protects the steam and alkaline liquid pipes, and serves also to strain the liquid from the stock under treatment. The boilers are arranged in pairs, so that the steam arising from the boiling of the alkaline and other contents of one boiler is injected into the other. The rotary-boilers are heated by a furnace below, and the chimneys pass through the cylindrical-bottomed vats above.

Fig. 4012 is an apparatus for reducing straw to "half-stuff" for the manufacture of paper. The straw, after being cut up

Fig. 4012.



Easton and Thiry's Straw-Boiler.

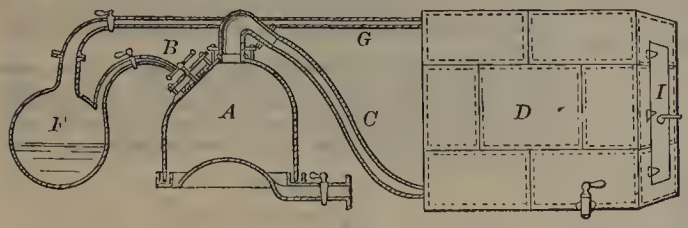
into short lengths, is immersed in an alkaline solution, and subjected to steam pressure in a boiler, after which it is washed and discharged from the boilers by the aid of a copious stream of water. The boilers are charged from above with stock and with water. The paper stock is stirred by chains on a rotating shaft, and is removed by lifting valve *L*. The fire is on a movable car *E*.

Robbins and Southmayd's apparatus for treating bamboo and similar fibers consists of a retort *A*, boiler *F*, and digester *D*. Heat is applied to the retort and boiler, and vapor from oleaginous substances in the first, and steam from the second, are conveyed through the pipes *C G* to the digester *D*, in which the fiber is placed.

The boiler and retort have direct communication through the pipe *B*, and each pipe is provided with a cock by which the proportions of steam and oily vapor admitted to the digester may be regulated, or either may be cut off. *I* is a door for entering or removing the fiber.

The spread of intelligence and the consequent demand for more books and newspapers has rendered the supply of rags entirely inadequate to fill the demand for paper stock. In working raw material some eliminative process became necessary.

Fig. 4013.



Boiler for Bamboo Fiber.

See the following United States patents, Nos.

1,753*	41,812	55,835
4,093	43,015	57,947
6,980	43,073	71,728
7,497	45,791*	73,138
9,910	45,845	106,135
11,987	47,539	109,595
17,381	50,266	110,873
20,294	51,430	113,502
24,484*	51,571	114,301
24,819	52,543	115,327
25,418	52,544	116,980
26,199	52,694	117,427
26,202*	54,308	119,465
38,901	54,510	131,749
40,659	55,418	

The principal methods now in use in England of preparing paper pulp by chemical means are those of Sinclair, Houghton, Lee, Deininger, Ungerer, Thode, and Lahousse, and the special processes of Belgian and Alsatian manufacturers, such as Orioli, Jarosson, and Bushaert, Moerman, Lauhuhr, Bastit, Rieder, and others. The general principle upon which all these chemical methods is based is the treatment of vegetable material containiug the fibrous matter with alkaline lyes under high pressures of steam and corresponding temperatures for a greater or less time, in order to separate the fibrous matter from the gluten, gum, starch, etc.

The chemical methods in the production of paper pulp, although somewhat cheaper than the mechanical methods, are not sufficiently so to effect an important alteration in the cost of paper The inventors of chemical processes have had to look for a saving somewhere, in order to effect such a desirable result. Many attempts have been made to recover the alkali, and, although as high as eighty-five per cent of the alkali was recovered by Sinclair, others failed altogether or produced very unsatisfactory results, and now the processes of boiling with alkaline solutions have become so much improved, that the recovery of the alkali has become of secondary importance. These chemical processes being all founded upon one general principle, the differences in the apparatus employed are simply in details of construction. They consist mostly of cylindrical vessels, heated either directly or by steam from a steam-boiler. In the latter case, the boiler apparatus is provided at a short distance from the bottom with a perforated plate, which separates the material to be treated from a certain serpentine steam-pipe. The boiler apparatus has also to be provided at the lower end with a man-hole for the drawing out of the finished materials. The differences in the details of the various apparatus have certain advantages and disadvantages which do not alter the main conditions. Fry's process (Swedish) consists in boiling the wood in water or alkalies, under pressure of steam of from five to six atmospheres. It can only be applied to sawdust, and requires much more time than the others. Adamson's process consists in the employment of hydrocarbons for digesting woody fiber. The ligneous matter is placed between two perforated plates in a boiler heated by a steam-coil and filled with benzine, petroleum, gasoline, or equivalent liquid, which is vaporized, and after condensation in a coil passing through a water chamber above returns again to the boiler, whence it is drawn off by appropriate cocks. The disintegrating effect, though not so thorough as that produced by alkalies, is yet sufficient for the purpose.

Sinclair's method is employed in reducing wood, hamboo, straw, thistles, etc. The material partially comminuted is treated with a solution of caustic soda at a temperature of 360° to 375° Fah. (11 or 12 atmospheres pressure). The boiler is vertical, and consists of an inner perforated and exterior close cylinder, between which and the wall of the brick-work furnace is an open space, permitting the products of combustion to surround the boiler, whose interior perforated shell is charged with the fiber and filled up with water, which, passing through the apertures, constitutes a water-jacket between the two shells, so as to prevent overheating.

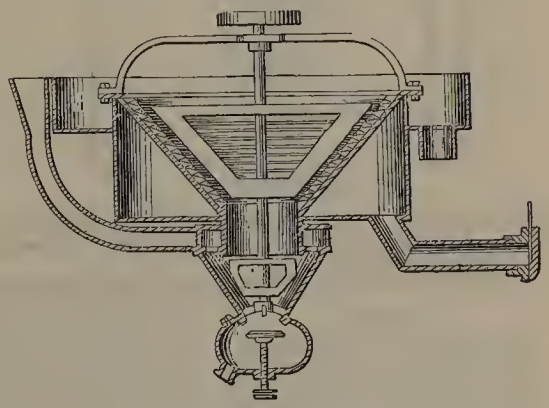
A cylindrical receiver, connected by a pipe with the boiler beneath, is filled with concentrated lye, and the application of heat causes a circulation and interchange of the steam and fluids to ensue, removing the silicates, resinous matter, etc. The fiber is withdrawn from the apparatus, washed, bleached with chloride of lime, and afterward treated in the centrifugal machine or hydraulic press. The lye is passed through an evaporator having inclined flues, by which about 85 per cent of the soda is recovered.

When superheated steam is employed for heating the disintegrator, a special form of boiler, having inclined water-tubes between which the products of combustion pass, is employed; these, after circulating below, through, and round the boiler, descend a downcast flue to reach the chimney. It may be noted that steam-heated digesters require a less quantity of alkali, and complete the process in shorter time, than those heated by direct firing. In treating esparto, straw, etc., a temperature of 312° to 320° Fah. is sufficient, instead of 360° to 375°, as required for wood.

* Reissued.

Pulp-dress'er. A machine for removing specks and knots from paper-pulp. The diluted pulp is passed into a screen in which the specks, by superior specific gravity, are collected into a receiver, from

Fig. 4014.



Sellers's Paper-Pulp Dresser.

whence they may be discharged. The knots too large for the meshes are delivered over the edge of the screen into an annular trough.

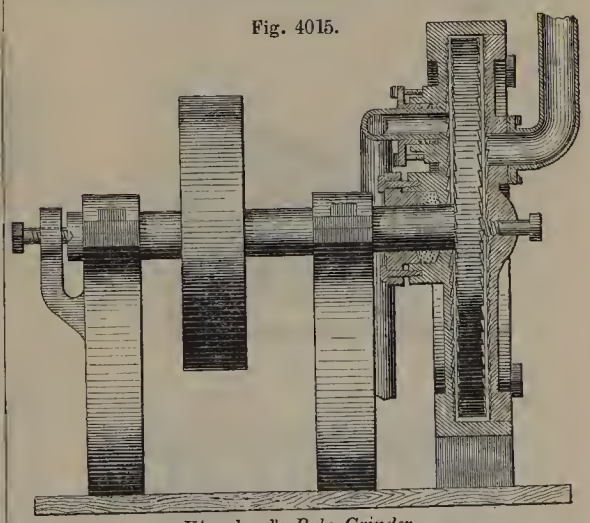
Pulp'er. 1. An apparatus for freeing the coffee-berry from the fleshy pulp by which it is surrounded. See COFFEE-MACHINERY.

2. A machine for reducing paper stock to pulp. See PULP-DIGESTER; PULP-GRINDER; PULP-MACHINE.

Pulp-grind'er. A machine for grinding paper stock for pulp.

Kingsland's pulp-grinder (1848 and 1856) has a closed reservoir with serrated circular sides which form the opposing sur-

Fig. 4015.



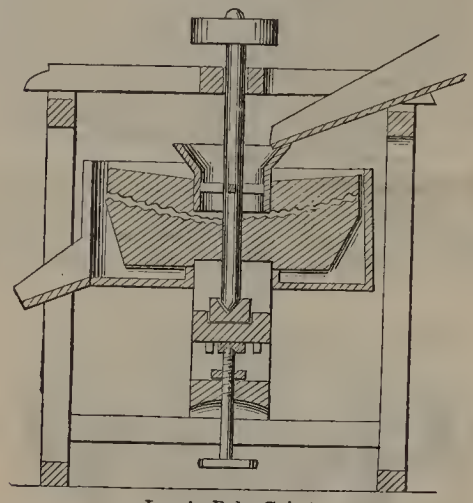
Kingsland's Pulp-Grinder.

faces to the toothed grinding-disk. The paper stock to be ground is fed in with a current of water at one pipe and dis-

charged at another, the pressure being obtained by a hydrostatic column, and the rate of passage determined by means of the regulatable discharge-aperture.

Fig. 4016 has grinding surfaces on a vertical shaft in the manner of millstones. The half-ground stuff is fed in at the spout to the eye of the stone, is discharged at the skirt, and leaves the tub by the lower spout.

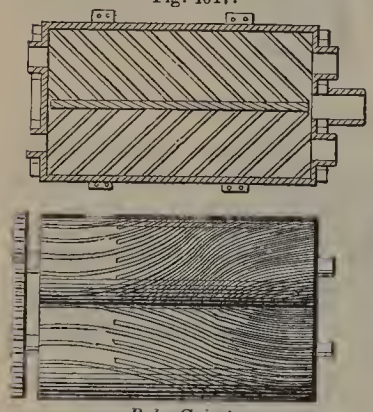
Fig. 4016.



Jones's Pulp-Grinder.

In Fig. 4017 the spirally ribbed cylinders are geared together, the edges of the ribs acting as shears to cut the material. The case has ribs in opposite directions to those on the rollers, and acting with them to disintegrate the pulp. A longitudinal bar is placed below and nearly touching the engaging portions of the rollers. The hopper is near one end and the exit pipe centrally situated at the other. The cutting-ribs on the rollers are multiplied toward the exit.

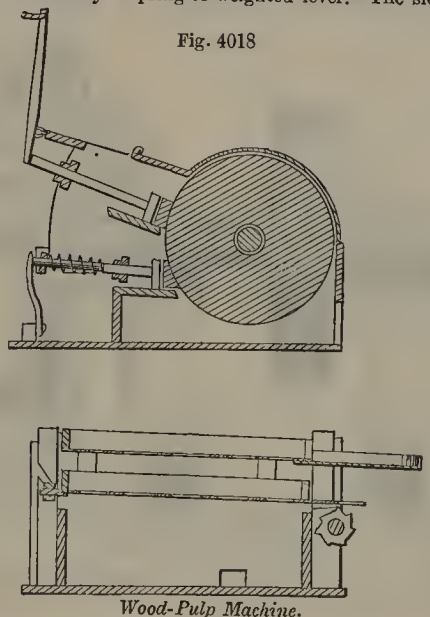
Fig. 4017.



Pulp-Grinder.

Fig. 4018 is a form of machine for grinding wooden blocks into pulp. The blocks are pressed against the grindstone by a spring or weighted lever. The sieves are made of metallic plates, which are perforated by elongated meshes, separating the pulp according to the diameter of the fibers, and delivering the different qualities into different receptacles.

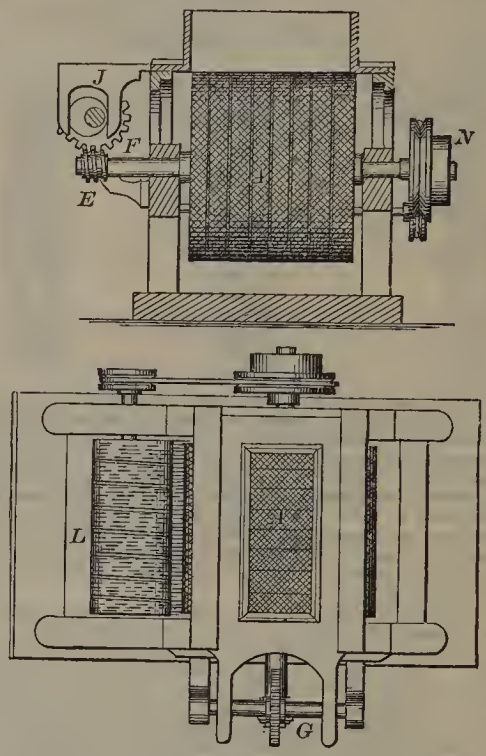
Fig. 4018



Wood-Pulp Machine.

Fig. 4019 is an apparatus for grating wood to form paper pulp. The cylinder *A* has a surface adapted for grating, rasping, or filing, and is rotated by a pulley *N* at the same time that a traversing motion is imparted by a worm-wheel on the shaft *G*, and the worm *E* on the shaft *F*, to a hopper above, which contains the wood. The wheel is journaled in an eccentric in the slot *J* to cause this motion. *L* is a cleaning cylinder covered with card leather, and running in contact, or nearly so, with the cylinder *A* for removing the pulverized wood therefrom. See also WOOD-PAPER.

Fig. 4019.

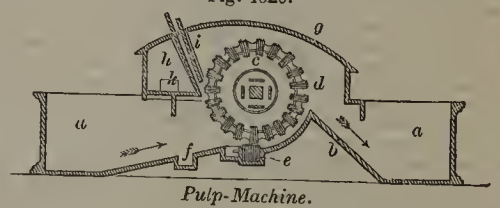


Wood-Grinder.

Pulp'ing-ma-chine'. A masticator for reducing roots to a pulp for food. Revolving knives and spikes are the essential feature of the machine. A sausage-grinder will do it.

Pulp-ma-chine'. (*Paper-making.*) A machine for reducing *half-stuff* to a fine pulp. It is similar to the *half-stuff engine*, consisting of an oblong iron vat *a* rounded at the ends and divided by a partition *b*, over which is journaled a cylinder *c* having grooves into which chisel-edged blades *d* are inserted in sets of 3, generally to the number of 60; beneath these and set at an angle therewith, other cutters *e* are fixed in the bottom of the vats; the distance between the two may be adjusted by raising or lowering the roller *c*.

Fig. 4020.



Pulp-Machine.

The part *e* of the bottom is sloping, and has a depression *f* for the reception of grit.

The machine is charged with dry half-stuff, to

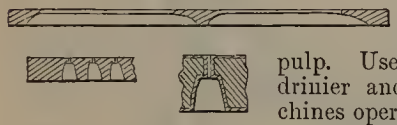
which water is added, and the cylinder *c* caused by appropriate gearing to make from 150 to 200 revolutions per minute, causing the stuff to pass between the cutters in the direction indicated by the arrows; a hood *g* is provided to prevent the pulp from being thrown out of the machine, and one side of this is a sieve *h* with a removable cover *i*, through which the foul water expelled from the pulp passes and is discharged through the opening *k*. See also HALF-STUFF MACHINE.

Pulp-me'ter. (*Paper-making.*) An apparatus invented by Cowan of Valley Field, near Edinburgh, for measuring out a uniform and exact supply of pulp to the paper-machine, according to the width and thickness of the sheet of paper to be made. It consists of a cup having an adjustable slide, which may be set so as to deliver from a box connected with the pulp-chest and kept constantly filled with the exact quantity of pulp required for a sheet of given dimensions, thus securing uniformity of thickness.

Pulp-mill. A machine for grinding paper pulp. See PULP-GRINDER; PULPING-MACHINE.

Pulp-strain'er. A sieve for stopping knots and hard or bulky portions of material ground to form paper pulp. Used in the Fourdrinier and cylinder machines operating on cotton and linen stock; it is known as a *knotter*. In preparing paper pulp from wood, straw, and other unspun fiber it is a strainer with fine meshes, and is made of fabric or wire-cloth (Voelters, 1869); of finely slitted thin plates (Sweet, 1833); rollers closely assembled in parallel order (Bishop, 1845); slats laid in louver order (Hebard, 1839); of slats with facings of electro-plated metal (Winchester, 1869); of hard rubber parallel slats (Curtis, 1867). Others might be noticed.

Fig. 4021



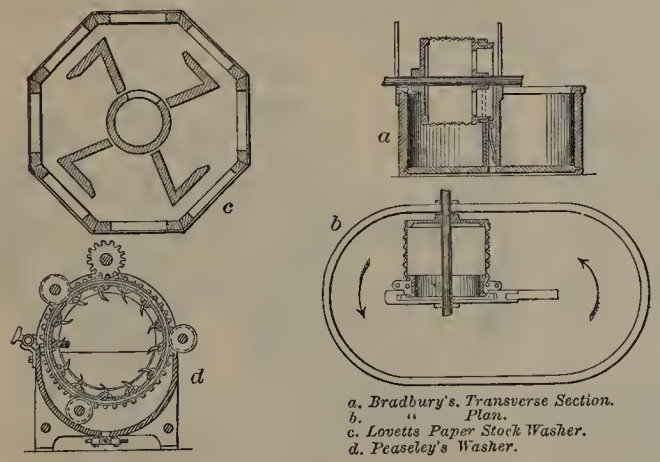
Winchester's Pulp-Screen.

Fig. 4022.

Curtis's Screen-Plate.

Pulp-wash'er. A machine for removing dirt or foreign matters from paper pulp. The machines are of various kinds, as will be seen by examining those shown in Fig. 4023, which will be understood without lengthy explanation. Means are provided for supplying fresh water and discharging foul water without carrying off the stock. A screen is employed to separate grain, gravel, etc. See also PULP-DRESSER.

Fig. 4023.

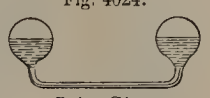


a. Bradbury's. Transverse Section.
b. " Plan.
c. Lovetts Paper Stock Washer.
d. Peaseley's Washer.

Pulp-Washers.

Pulse-glass. An instrument invented by Dr. Franklin and constructed like a *cryophorus*, but intended to exhibit the ebullition of liquids at low temperatures. The bulbs are connected by a slender stem and partially charged with water, the supernatant air having been expelled by boiling, and the opening hermetically sealed by a blow-pipe. By grasping one of the bulbs the heat of the hand will cause the formation of vapor and drive the liquid into the other bulb, producing a violent ebullition in the latter.

Fig. 4024.



Pulse-Glass.

Pul-som'e-ter; Pul-sim'e-ter. 1. An instrument for measuring the force or frequency of the arterial pulsation. A *sphygmometer*.

Santorio of Padua describes in his "Commentarius in Primum Fen Primi Libri Canonis Avicennæ," Venet. folio, 1626, an instrument of his invention for measuring the force of the pulse. He was also the first to apply the thermometer to measure the heat of the skin in disease and at different periods of the same disease. See SPHYGMOMETER.

2. A name applied to a form of vacuum pump. See STEAM-VACUUM PUMP.

Pul'ver-iz'er. See a number of typical forms on Plate XXXIV. illustrative of ORE-MILLS; also "Blake's" Crusher, Fig. 3417. Also AMALGAMATOR; ARRASTRA; BONE-MILL; CEMENT-MILL; CHILIAN-MILL; DISINTEGRATOR; EDGE-MILL; PAN; QUARTZ-MILL; STAMP. See list under MILL.

Pul'ver-iz'ing. (*Gunpowder-manufacture.*) A mill in which the ingredients are separately reduced to an impalpable powder before being transferred to the incorporating-mill.

In the United States this is generally effected by the rolling-barrel.

Pum'ice-stone. A light cellular and fibrous rock of grayish-white color produced by volcanic action. Extensively used in the arts for smoothing and polishing purposes. It is regarded as a form of trachytic lava, in which a porous structure has been induced by the expansion of gas while in a plastic state. Campo Bianco, one of the Lipari Islands, which is entirely composed of this substance, is the principal source of supply. It is frequently employed in its natural condition, but more generally in the state of powder.

Pump. 1. (*Hydraulics.*) A device for lifting water by the motion of a piston in a cylinder.

Whether they were invented by Danaus, who dug the wells in Argos, 1485 B. C., or by Ctesibus of Alexandria, about 224 B. C., it is not possible to determine. In either case, the origin is Egyptian, and that is the most likely part of the statement. Danaus is said to have been the brother of the Pharaoh Rameses, and to have carried many useful devices from the Nile to the Peloponnesus.

The piston working in a cylinder is the *piston-blower*, a very ancient form of blast for the native smelting-furnaces of Asia, Africa, and Europe. See page 1717.

The water-pump of Ctesibus of Alexandria was described by Hero, 150 B. C., and the invention may be much older than the time of this distinguished mechanician and physicist, who was also a barber, as it certainly was in quite a com-

plicated form. It consisted of two single-acting pistons in as many cylinders, which raised water on the up-stroke and expelled it on the down-stroke into a chamber which received the water from both pumps. See FIRE-ENGINE.

Vitruvius ascribes the invention of the pump to Ctesibus. He did not understand the *lift*, but the *force* pump. The pressure of the atmosphere was not estimated then. It was described by the Spanish Saracens, and correctly determined by the Italian Torricelli.

The true laws of the equilibrium of fluids were discovered by Archimedes and rediscovered by Stevinus and Galileo. Of the latter Milton writes, in reference to his tour in Italy: —

"There it was that I found and visited the famous Galileo, grown old, a prisoner in the Inquisition, for thinking in astronomy otherwise than the Franciscan and Dominican licensers thought."

The next we hear of the piston is in the air-pump of Otto Guericke of Magdeburg, and in the steam-engine of Dr. Papin of Blois. If we knew better what the philosophers of Alexandria and Cordova had been doing in the mean time, we should probably find that the piston-pump was not entirely laid away for fifteen or sixteen centuries.

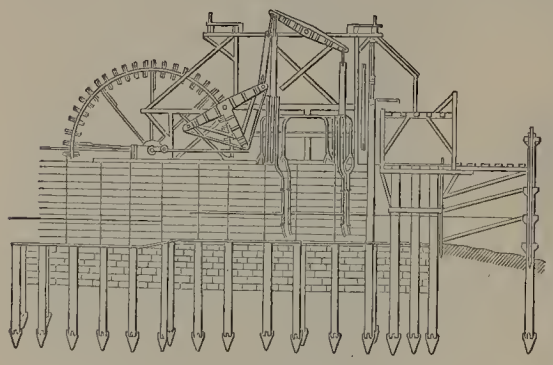
Dr. Papin was the first, so far as we know, to suggest raising water by means of a steam-*engine*, 1698. The devices of the Marquis of Worcester and Savery were not *engines*. They were water-raising devices, in which steam pressed upon the surface of water in a tank and raised it to a hight proportioned to the pressure. They did not differ essentially (except in the size of the parts) from the inventions of Baptista Porta and Leonardo da Vinci. Savery and Worcester proposed to make their apparatus available for driving machinery by "raising water to turn a water-wheel," which is all nonsense. Papin's was an *engine*. See STEAM-ENGINE.

A number of large water-raising machines were constructed at various points on the Continent of Europe during the seventeenth and eighteenth centuries, which are curious, but operate by modes which are now antiquated.

Among these may be noticed the "Machine de Marly," constructed by Ranuequin, 1682, to raise water for the fountains of Marly and Versailles.

It was situated on the Seine between Marly and Lachaussèe, and consisted of 14 water-wheels, which first raised the water to a cistern 150 feet high and 600 feet distant, then worked the

Fig. 4025.



Machine de Marly.

balance-beams of the pumps which raised the water to a second cistern, 175 feet above the first and 1,944 feet from the river. From thence it was lifted by other pumps to a strong tower or reservoir, 502 feet above the river and 3,684 feet from it. From thence the water was conveyed by an aqueduct to its destination. This was a piece of the kingly magnificence of "le Grand Monarque," and was far ahead of what was enjoyed by Paris. The pumping-machine is said to have cost $1,600,000.

The cut is a longitudinal section showing one of the fourteen water-wheels. On the bed of the river a floor was laid on piles filled in with masonry; 14 feet above this was the platform which supported the pumps. To the axle of the great wheel a crank was attached which communicated motion to the balance-beam, and this worked the piston-rods of four pumps on each side, which sucked and forced water alternately.

The pumps at the first and second cisterns were of a similar character, and were worked by rod-and-chain connection from the water-wheels in the river.

The machines used by Belidor, Ducille, Desargues, Wahl, Morel, etc., are described by Cresy. Several of them are only peculiar in the modes of obtaining the reciprocating motion of the pistons from the rotation of the water-wheel.

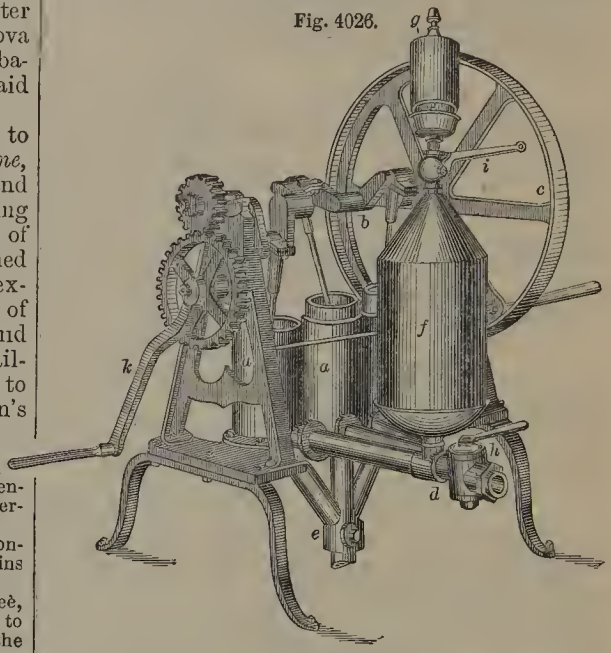
The chapelets used by the architect Perronet in pumping out the coffer-dams of his numerous bridges are described under CHAIN-PUMP.

The bucket-wheel used by Perronet is described under NORIA (which see).

See also BASCULE; SCOOP-WHEEL; TYMPANUM.

The work of a man on a pump is estimated as equivalent to an effort of 17½ pounds exerted through 2½ feet in 1 second; or, 150 feet per minute = 9,000 feet per hour = 157,500 foot pounds or 70 foot tons per hour = 560 foot tons per day of 12 hours.

Fig. 4026.

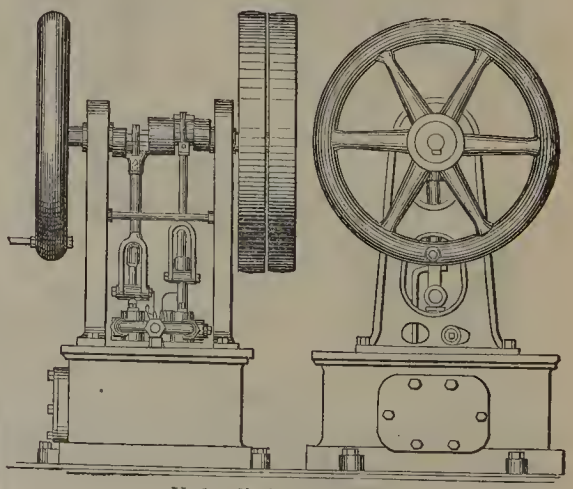


Alarm-Pump.

The most favorable length of stroke on fire-engines is from 30 to 35 inches.

The power necessary is about 1 man for every 22 cubic inches of pump-barrel; double this power if double-acting.

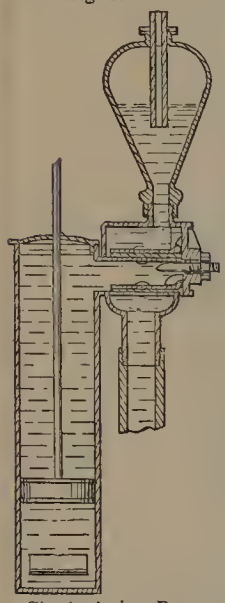
Fig. 4027.



Hydraulic-Pressure Pump.

Haskell's alarm-pump for nautical use has three cylinders *a a a*, the pistons of which are connected to crank-arms arranged at equal angles around the shaft *b*, and operated, when worked as a pump, by an arm on the fly-wheel *c*. The three delivery-pipes from the cylinders coalesce at *d*, so as to form but one; their respective suction-pipes are also united above *e*, and the pipe formed by their junction is provided with two valves, one of which opens connection with the pipe leading to the hold and the other with a hose leading overboard, when it is desired to wash decks. An air-chamber *f* is located above the pipe *d*, and over this is a whistle *g*, used for sounding signals or alarms. For this purpose the pipe *d* is closed by turning the cock *h*, when, by turning the fly-wheel, air, admitted through a valve in the suction-pipe, is forced into the cylinder and allowed to escape by depressing the lever *i*, which works a valve. When desired to increase the supply of air to effect a more rapid succession of sounds, the crank *k* is employed.

Fig. 4028.



Single-Acting Pump.

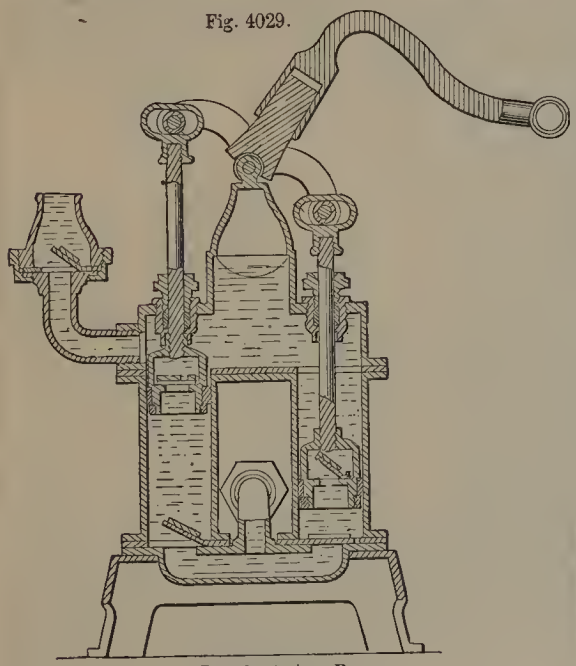
The hydraulic-pressure pump (Fig. 4027) is intended for forcing water in working presses, etc. It is provided with a cistern, and has suitable suction and delivery pipes with appropriate valves, and may be driven either by hand-power or by belt-and-pulley connections. See Plate XXV. and page 1157.

The principal distinctions of pumps are into *single* or *double* acting, *lift* or *force*, *reciprocating* or *rotary*, etc. These names indicate construction. Other names have reference to purpose, etc.

See under the following list: —

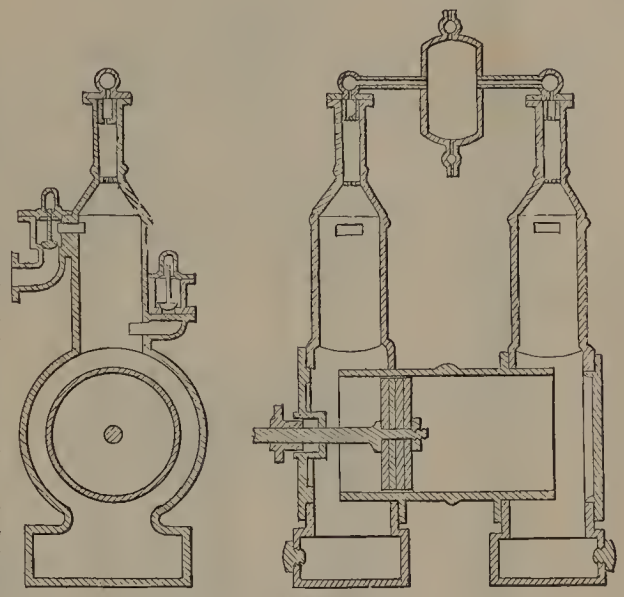
Air-pump.
Archimedean screw.
Aspiring-pump.
Bare-pump.
Bar-pump.
Barrow-pump.
Beer-machine.
Bellows-pump.
Bilge-pump.
Bottle-pump.
Brake-pump.
Breast-pump.
Brine-pump.
Burr-pump.
Cattle-pump.
Centrifugal pump.
Centripetal pump.
Chain-pump.
Change-pump.
Chapelet.
Circular-brake pump.
Circulating-pump.
Cistern-pump.
Cold-water pump.
Cupping-pump
Deep-well pump.
Dental pump.
Diaphragm-plunger pump.
Diving-bell pump.
Donkey-pump.
Double-action pump.
Double-cylinder pump.

Fig. 4029.



Double-Acting Pump.

Fig. 4030.



Double-Acting Single-Cylinder Pump.

Double-piston pump.
Draining-pump.
Driven-well pump.
Eccentric pump.
Ejector.
Elastic-piston pump.
Feed-pump.
Fire-engine pump.
Force-pump.
Forcer.
Fountain-pump.
Garden-engine.
Garden-pump.
Garden-syringe.
Giffard injector.
Hand-pump.
Hogger-pump.
Horse-power pump.
Hot-water pump.
Hydrapult.
Hydraulic-pressure pump
Hydrostatic-press pump.
Injector.
Jet-pump.
Leech. Artificial
Lift-pump.
Locomotive-pump.
Measuring-pump.
Mining-pump.
Monte-jus.
Noria.
Oil-pump.
Oscillating-pump.
Paternoster-pump.
Pendulum-pump.
Plumber's force-pump.
Plunger-pump.
Pneumatic pump.
Portable pump.
Pressure-pump.
Pump-bit.
Pump-dale.
Pump-head.
Pumping-engine.
Pump-lamp.
Pump-packing.
Pump-piston.
Pump-spear.
Pump-valve.
Rope-pump.
Rotary pump.
Saliva-pump.
Sand-pump.
Screw. Archimedean
Ship's pump.
Spiral pump.
Steam-jet pump.
Steam-pump.
Steam-vacuum pump.
Stomach-pump.
Submerged pump.
Suction-pump.
Syringe.
Test-pump.
Tympanum.
Vacuum-pump.
Water-ram.
Water-screw.
Water-snail.
Wind-pump.
Wrecking-pump.

See WATER-ELEVATOR for other forms of water-raising contrivances.

Pump-back. A wooden casing over a chain-pump to receive the water when raised.

Pump-bit. A wood-boring tool of relatively large diameter and a long shank. It is adapted to be rotated by a cross-handle, and is used in boring out timbers for pump-stocks and wooden pipes. It has a routing cutter and grooved barrel. See BIT.

Pump-bob. A species of bell-crank lever employed for converting the rotary motion of a steam-engine into reciprocating motion for operating a pump-piston. In the illustration, the pitman is connected to a crank-pin on the pumping-wheel; the braces, standard, and bed-piece of the bob are mounted on a rock-shaft journaled, and supported

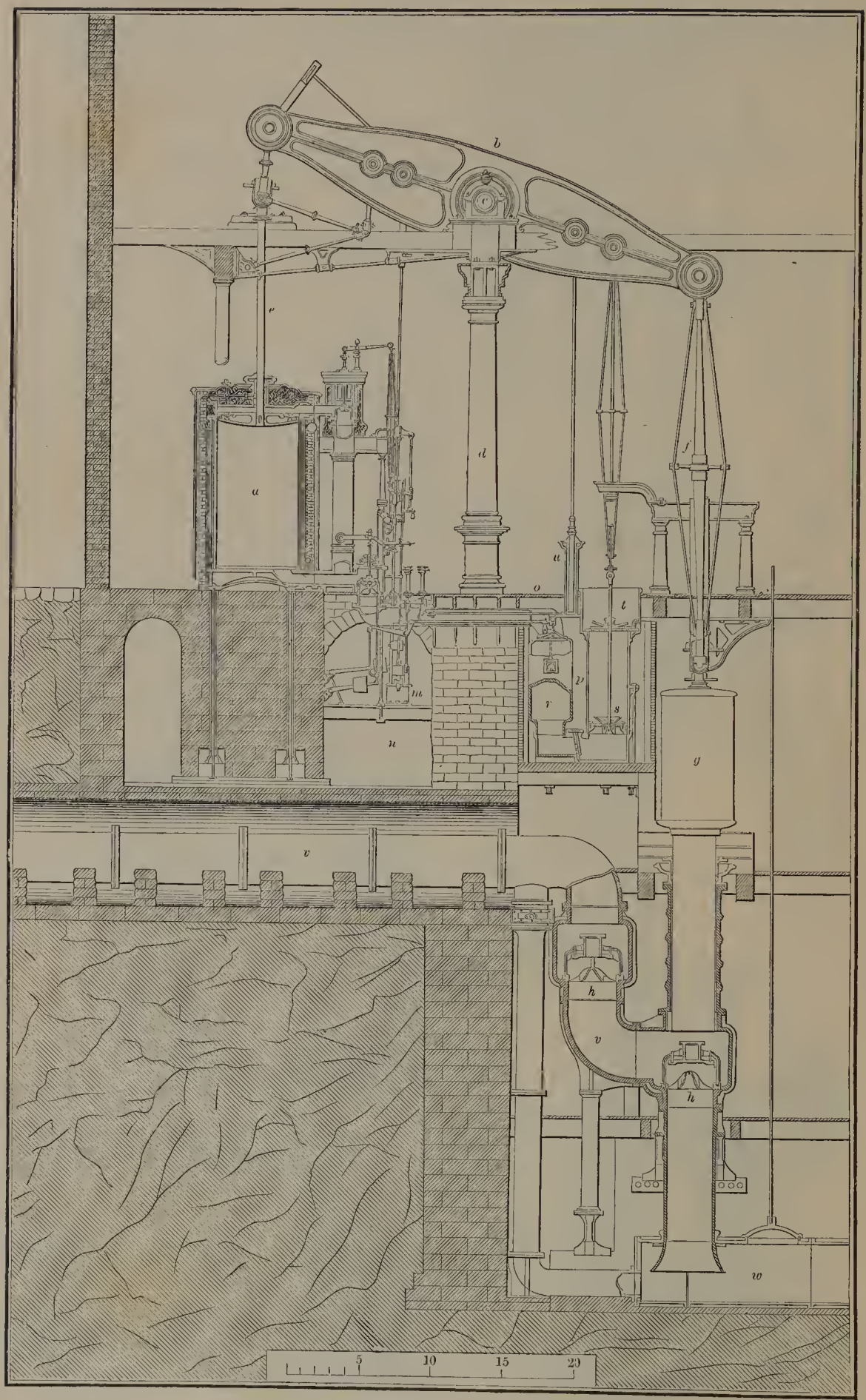
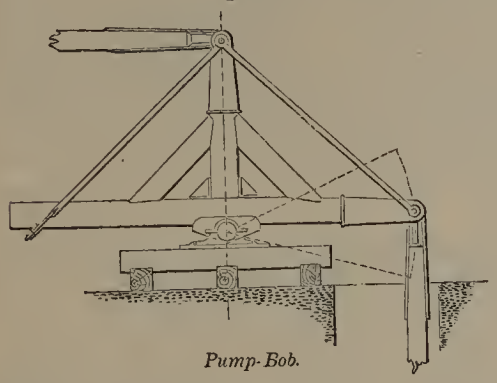


PLATE XLIV. PUMPING-ENGINE, LOUISVILLE WATER-WORKS.

(*Theodore R. Scowden, Engineer.*)

See page 1829.

Fig. 4031.



Pump-Bob.

on the frame; the bed-piece and pump-piston are connected, as shown on the right.

Pump-box. *a.* A cap or case covering the top of a pump.

b. The casings of the upper and lower valves are the *upper* and *lower* pump-boxes.

Pump-break. The handle or lever by which a pump is worked.

Pump-chain. A long chain with buttons forming valves at proper distances, working on two wheels, one above and one below, and passing down through one wooden tube and returning upward by another.

Pump-cheeks. A forked piece serving as a fulcrum for the handle.

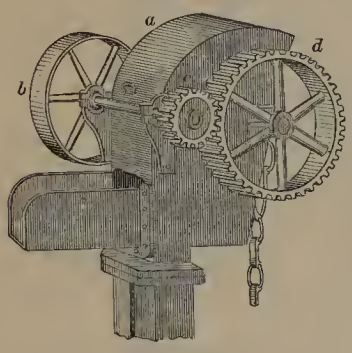
Pump-dale. (*Nautical.*) A pipe to convey water from the pump-cistern through the ship's sides.

Pump-drill. An upright drill acting by percussion.

Pump-gear. (*Nautical.*) The apparatus used in pumping on shipboard.

Pump-head. An arrangement for causing all the water raised by a chain-pump to be directed into the discharge-spout instead of permitting a part to be thrown off by centrifugal force. In the figure, *a* represents the pump-head; *b*, driving-pulley; *c*, pinion driving the spur-wheel *d*, around the axis of which the chain passes.

Fig. 4032



Pump-Head.

Pump-hook. A hook used for setting the lower pump-box in the barrel.

Pump'ing-en'gine. A steam-engine for raising water.

The engines of the Louisville Water-Works, shown in Plate XLIV., are on the Cornish plan. The engines are exactly alike, working each a single-acting lift and force plunger-pump. The dimensions of the principal parts of the engines and pumps are as follows, viz.: Steam-cylinder *a* 70 inches diameter, stroke of steam-piston 10 feet. The beam *b* for each engine is double; the two members, 3 feet 5 inches apart from center to center, are each 31 feet 10 inches long between end centers, 6 feet 9 inches deep in the middle, with 3-inch thickness of web and 9 inches width of center rib and outside flanges; the cylinder and pump ends of the beam are equal in length, each pair of beams weighs 42 tons. The beam vibrates on a main center or shaft *c* 20 inches diameter, 9 feet 8 inches long, with journals 15 inches diameter, and 19½ inches bearing. The plummer-blocks, for the beam centers of both engines, rest in pedestals bolted to a massive cast-iron entablature, which (extending transversely across the house and into the brick walls) is supported by four Tuscan columns *d* of cast-iron, standing on and anchored to the beam wall, by means of arched cast-iron bed-plates, built in the masonry. The piston-rods are guided by parallel motions, and the pump connecting-rods by cross-heads and slides; piston-rods *e* 6¼ inches diameter and 16 feet long each; pump connecting-rods *f* 8 inches diameter and 28 feet long each.

The pump-barrels are 36 inches in diameter each, plungers 36 inches diameter, with stroke same as steam-piston, 10 feet. The extreme lift of the pumps, when the river is at its lowest stage, is 21 feet 10 inches. The pumps are connected with the stand-pipe by two lines of 40-inch flanged pipes, provided each with a stop-gate near the stand-pipe. The pump-valves *h h* are of the kind known as Harvey and West's double-beat valve. The pumps and pump-mains to the stand-pipe have a circular waterway of 40 inches diameter throughout, thus admitting the introduction of pump-barrels 40 inches in diameter, and increasing the present pump capacity 23 per cent whenever the consumption of water will demand a greater supply than at present provided for.

The metal (cast-iron) of the pumps and pump-mains is from 2 to 3 inches in thickness, varying as the forms vary from the cylindrical to the oval or rectangular. All the joints are made with lead by means of flanges and bolts; the flanges are from 2½ to 3 inches thick, and from 4 to 6 inches wide, with 1¼-inch bolts.

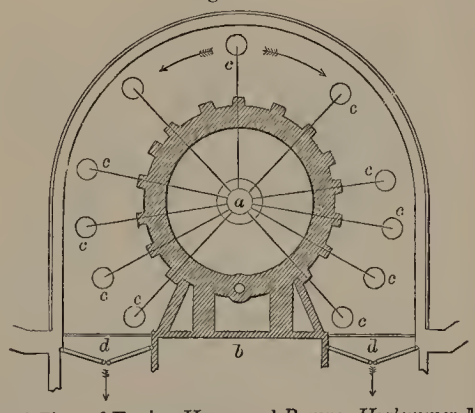
Each engine is provided with a battery of three single-flue Cornish boilers. The performance of the engines has been very satisfactory. The highest daily duty (calculated by the Cornish method) was 48,363,344 pounds of water raised 1 foot high per 100 pounds of coal; the highest monthly average was 35,957,629 pounds, and the yearly average duty 30,217,865 pounds. Cost of the engines and connections complete, $117,753.64.

The other parts of the engine are similar to those described under AIR-PUMP, CATARACT, CORNISH-ENGINE, etc., which see.

The *cataract m* is in the vault *n*; the *condenser* and *air-pump* are in the well below the main floor *o* of the engine-house. *p* is the cistern, *r* condenser, *s* bucket of air-pump, *t* hot-well. *w* is the induction water-pipe at the foot of the pump-stock, *v* the eduction main, *u* the feed-pump

The drainage of the Haarlem Lake in Holland, by which 45,230 acres of land were reclaimed, was effected between the years 1848 and 1853 by steam-pumping engines. These were three in number, named the *Leeghwater*, *Cruquius*, and *Van Lynden*, from three eminent men who had at different times, the first as far back as 1623, proposed plans for the drainage of this lake. The Leeghwater was the first erected, working 11 pumps of 63 inches diameter and 10 feet stroke. As a preliminary step, an earthen dam was constructed at the edge of the lake and inclosing about 1½ acres of its surface; the water was withdrawn from this by pumping with a small steam-engine, and foundation piles, 1,400 in number, were driven to the depth of 40 feet until a stratum of hard sand was reached. Upon these piles, at

Fig. 4033.



Ground Plan of Engine-House and Pumps, Harlemmer Meer.

a depth of 21 feet below the surface of the lake, a strong platform was laid, on which a wall pierced with arches was built at a distance of 22 feet from the site of the engine-house; over this wall, and connecting it with the engine-house, was laid a thick flooring of oak. The pumps were supported by the lower platform, their heads passing through the flooring and extending about 3 feet above it. The water drawn up by the pumps was received in the space between the wall and the engine-house, and discharged through gates into canals leading to the sea sluices.

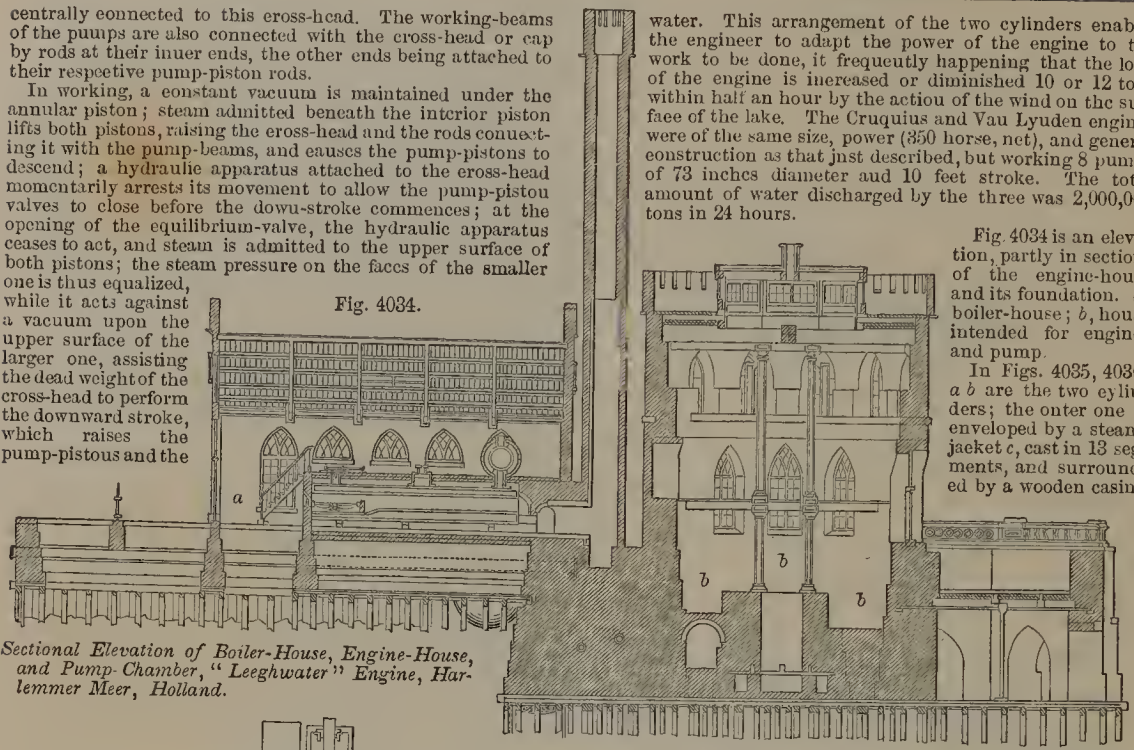
Fig. 4033 represents this arrangement in plan; *a* is the engine, *b* the boiler-house, *c c* the pumps, *d d* the discharge sluices.

The engine has two steam cylinders, one within the other, the outer being 144⅜ inches in diameter and 1½ inches thick, and the inner 84½ inches in diameter and 1¼ inches thick; between the inner cylinder and the cylinder head, which is common to both, is a space of 1½ inches. The piston of the outer cylinder is annular, and is connected with a circular cross-head by four rods; the main piston, that of the interior cylinder, is

centrally connected to this cross-head. The working-beams of the pumps are also connected with the cross-head or cap by rods at their inner ends, the other ends being attached to their respective pump-piston rods.

In working, a constant vacuum is maintained under the annular piston; steam admitted beneath the interior piston lifts both pistons, raising the cross-head and the rods connecting it with the pump-beams, and causes the pump-pistons to descend; a hydraulic apparatus attached to the cross-head momentarily arrests its movement to allow the pump-piston valves to close before the down-stroke commences; at the opening of the equilibrium-valve, the hydraulic apparatus ceases to act, and steam is admitted to the upper surface of both pistons; the steam pressure on the faces of the smaller one is thus equalized, while it acts against a vacuum upon the upper surface of the larger one, assisting the dead weight of the cross-head to perform the downward stroke, which raises the pump-pistons and the water. This arrangement of the two cylinders enables the engineer to adapt the power of the engine to the work to be done, it frequently happening that the load of the engine is increased or diminished 10 or 12 tons within half an hour by the action of the wind on the surface of the lake. The Cruquius and Van Lyuden engines were of the same size, power (350 horse, net), and general construction as that just described, but working 8 pumps of 73 inches diameter and 10 feet stroke. The total amount of water discharged by the three was 2,000,000 tons in 24 hours.

Fig. 4034.

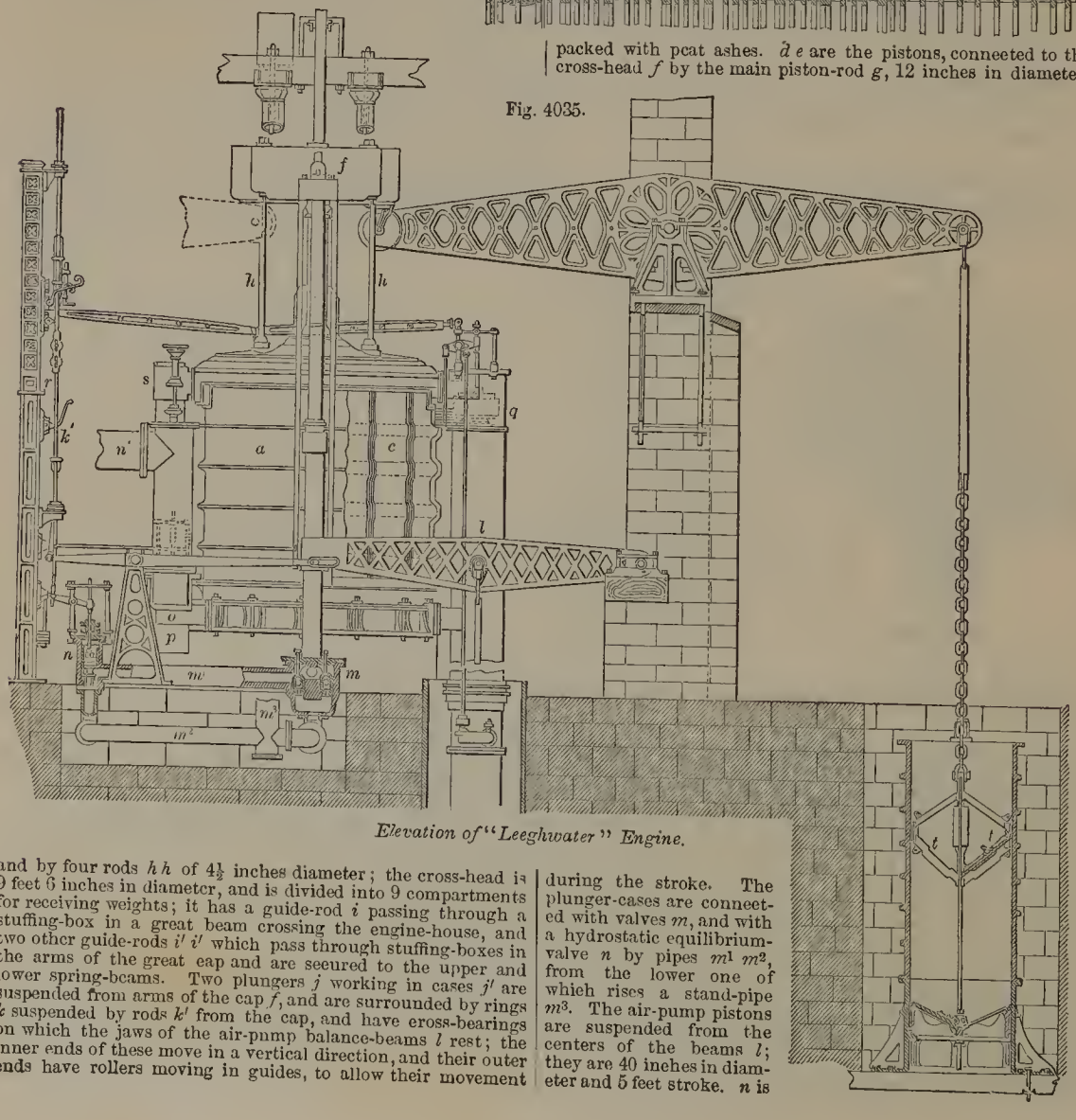


Sectional Elevation of Boiler-House, Engine-House, and Pump-Chamber, "Leeghwater" Engine, Harlemmer Meer, Holland.

Fig. 4034 is an elevation, partly in section, of the engine-house and its foundation. *a*, boiler-house; *b*, house intended for engines and pump.

In Figs. 4035, 4036, *a b* are the two cylinders; the outer one is enveloped by a steam-jacket *c*, cast in 13 segments, and surrounded by a wooden casing packed with peat ashes. *d e* are the pistons, connected to the cross-head *f* by the main piston-rod *g*, 12 inches in diameter,

Fig. 4035.



Elevation of "Leeghwater" Engine.

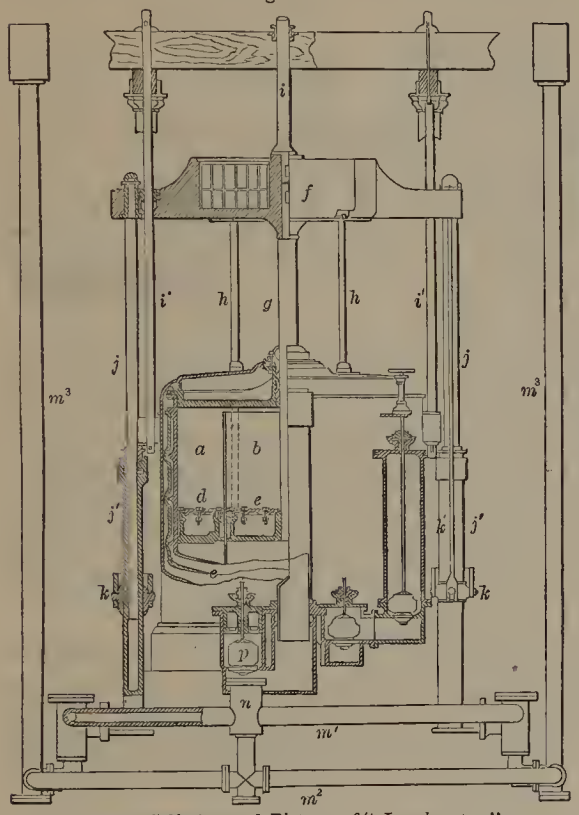
and by four rods *h h* of 4½ inches diameter; the cross-head is 9 feet 6 inches in diameter, and is divided into 9 compartments for receiving weights; it has a guide-rod *i* passing through a stuffing-box in a great beam crossing the engine-house, and two other guide-rods *i' i'* which pass through stuffing-boxes in the arms of the great cap and are secured to the upper and lower spring-beams. Two plungers *j* working in cases *j'* are suspended from arms of the cap *f*, and are surrounded by rings *k* suspended by rods *k'* from the cap, and have cross-bearings on which the jaws of the air-pump balance-beams *l* rest; the inner ends of these move in a vertical direction, and their outer ends have rollers moving in guides, to allow their movement during the stroke. The plunger-cases are connected with valves *m*, and with a hydrostatic equilibrium-valve *n* by pipes m^1 m^2, from the lower one of which rises a stand-pipe m^3. The air-pump pistons are suspended from the centers of the beams *l*; they are 40 inches in diameter and 5 feet stroke. *n* is

the steam-pipe, *o* induction-valve, *p* equilibrium-valve, *q* eduction-valve. The hand gear is connected to the weigh-post *r*, and the rods *k'* are worked by a lever and shaft operated by a pin on the sliding-ring *k*.

The induction and equilibrium nozzles are each connected to a separate port cast in the cylinder's bottom. The eduction-nozzle is connected by a pipe to the bottom of the cylinder, which communicates with the space under the annular piston, by which a vacuum is maintained under this piston.

The hydraulic apparatus which maintains the great cross-head *f* in upward position while the valves of the pump-pistons open, so as to prevent shock on the down-stroke, operates as follows: When the engine makes its up-stroke the plungers *j* are lifted, and the water from the stand-pipes and reservoirs flows through the valves, following the plungers during their upward movement. At the end of the stroke the spherical valves instantly close and the dead-weight is suspended at that point; the pump-piston valves *t* then fall out solely by their own weight. At the down-stroke the equilibrium steam-valve *q* and the hydraulic valve *n* are opened simultaneously, the water escapes from beneath the plungers to the stand-pipes m^3 and reservoirs by the pipes m^2, and the steam from the small cylinder passes by the pipe *s* round to the upper side of the two

Fig. 4036.



Steam Cylinder and Pistons of "Leeghwater."

steam-pistons, forming a steam equilibrium on each side of the smaller one and pressing against the annular piston, beneath which a constant vacuum is maintained.

The Leeghwater engine is furnished with five cylindrical boilers, each 30 feet long and 6 feet in diameter, with a central fire-tube 4 feet in diameter; a return flue passes under the boilers to the front and then splits along the sides. Over the boilers is a steam chamber 4 feet 6 inches in diameter and 42 feet long, from whence the steam is conducted by the pipe to the engine. The total steam space in the chamber, boilers, and pipes is nearly 1,520 cubic feet; this large volume effectually prevents primage, and secures a constant and uniform supply of steam to the engine.

The power is 400 horse, net; the Cruquius and Van Lynden engines can be worked up to 500 horse-power, if required.

The pair of pumps of the Chicago Water-Works have steam-cylinders of 44 inches diameter, 8 feet stroke. Water-pump 28 inches in diameter, double acting.

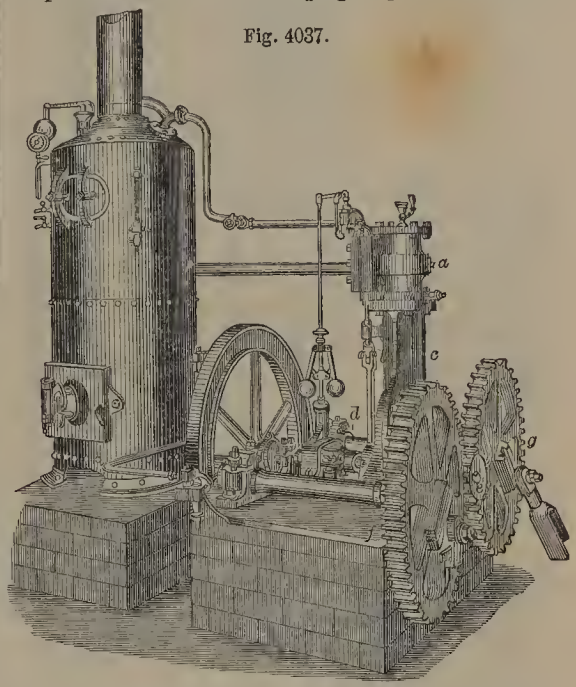
The Brooklyn pumping-engine cylinder is 85 inches diameter, 10 feet stroke; the bucket is 51½ inches in diameter.

The Pittsburg engine is 64 inches diameter, 11 feet stroke. The plungers are 4 in number, of 100 tons each, driving water into the Highland reservoir, 356 feet above.

The Lehigh Zinc-Works engine is 110½ inches, 10 feet stroke; estimated to raise 15,000 gallons per minute from a depth of 300 feet.

Fig. 4037 is a form of pumping-engine constructed at Leeds for the use of the state railways in India. *a* is the cylinder. The cross-head of the piston-rod reciprocates between the upright guides *b c*. The

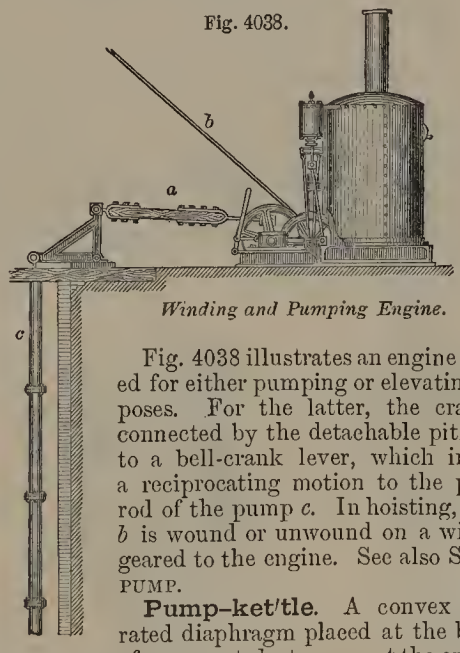
Fig. 4037.



Steam Pumping-Engine, India State Railways.

crank-shaft *d* carries on its outer end a pinion *e* gearing with the two wheels *f g*, to which the upper ends of the pump-pistons are connected by sliding forks in such a way that their stroke may be lengthened or shortened at pleasure.

Fig. 4038.



Winding and Pumping Engine.

Fig. 4038 illustrates an engine adapted for either pumping or elevating purposes. For the latter, the crank is connected by the detachable pitman *a* to a bell-crank lever, which imparts a reciprocating motion to the piston-rod of the pump *c*. In hoisting, a rope *b* is wound or unwound on a windlass geared to the engine. See also STEAM-PUMP.

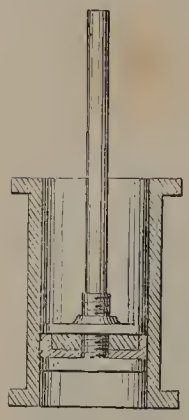
Pump-ket'tle. A convex perforated diaphragm placed at the bottom of a pump-tube to prevent the entrance of foreign matters. A *strainer*.

Pump-lamp. One having a pump employed for forcing up oil to the wick. Used in that class of lamps in which the reservoir is too distant to permit the oil to be drawn up by capillary attraction. It may be operated by hand or by clock-work mechanism, as in the Carcel lamp. See MECHANICAL LAMP.

Pump-pis'ton. The reciprocating disk within

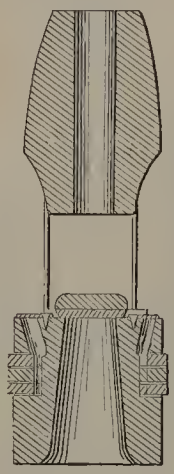
a cylinder by which the fluid is expelled. The example is a *plunger*-piston having no opening through it. The leather which works against the cylinder is expanded by the sub-caliber rubber disk when compressed by screwing down the upper disk.

Fig. 4039.



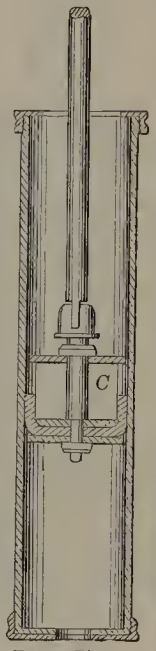
Pump-Piston

Fig. 4040.



Pump-Bucket.

Fig. 4041.

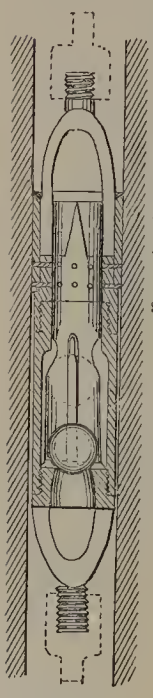


Pump-Piston.

In Fig. 4041, the leathern cup receives its shape and expansion from an elastic cylinder *C*.

Fig. 4040 is a bucket. The expansible packing is composed of a ring of a soft substance, as leather or rubber, interposed between and protected by sectional rings of a hard substance, as metal or wood. The rings occupy a peripheral chamber of the piston and expand together.

Fig. 4042.



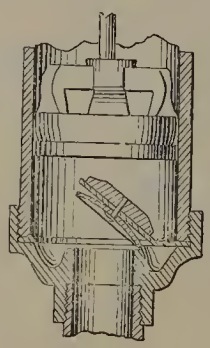
Pump-Bucket for Deep Wells.

Fig. 4042 is for deep wells. The packing is kept tight by the pressure of the water inside the same. The ribs constitute the cage of the valve, and permit the water to pass upward as the piston descends. See also PISTON.

Pump-scrap'er. A round plate used for cleaning out the pump-barrel.

Pump-spear. The rod which is suspended from the end of the brake or handle and attached at its lower end to the bucket or "upper box."

Fig. 4043.



Pump-Valve.

Pump-staff. The pump-spear in a hand-pump.

Pump-valve. A hinged, oscillating, sliding, rotating, or lifting plate, lid, or ball in the barrel, the bucket, or both, to alternately open and close the apertures as the piston reciprocates.

The piston of a pump is a *bucket* when hollow, or a *plunger* when solid. In the former case it has a valve which opens as the bucket descends, and closes as it rises.

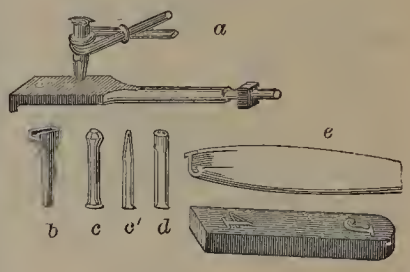
The lower valve of a pump is fixed in the pipe below the barrel, and rises as the bucket or plunger rises. See PUMP-PISTON.

Pump-well. (*Shipwrighting.*) A compartment extending from the ship's bottom to the lower or the upper deck, as the case may be, to contain the pump-stocks, etc. The *bilge-water* collects in the *limbers*, and is discharged through a spout called the *pump-dale*.

Punch. 1. A tool operated by pressure or percussion, employed for making apertures, or in cutting out shapes from sheets or plates of various materials.

In Fig. 4044, *a* is the common blacksmiths' round punch; they are also made square or quadrangular. The stem is preferably of octagonal form, enabling it to be readily turned by the tongs or by a withe twisted around it, and it is struck on the head by a hammer. The point is formed by drawing down from a steel rod and tempering. In using punches of this kind the work is interposed between the punch and a hole in the anvil.

Fig. 4044.



Punches.

b is a *seam-set* for closing up the seams made in joining the edges of sheet-metals on the *hatchet-stake*.

c is a hollow, and *c'* a solid punch; the cutting edges of the former meet at an angle of about 50°; *d* is a *riveting-set* or punch for the heads of rivets. These are struck upon a thin plate of lead or solder placed on the *stake*, or upon the stake itself, without the leaden plate. See BENCH-STAKE.

A punch for driving out a bolt is a *starting* or *teeming* punch.

Punches for cutting out the disks, called *planchets* or *blanks*, in coining, and those for making washers, are solid cylinders, accurately fitting a cylindrical hole in the bed on which the sheet of metal is laid for punching.

Punches for making wafers, lozenges, and other articles of similar shape cut from plastic material, are merely cylindrical tubes with a sharp cutting-edge.

Punches for cutting out gun-wads are hollow for some distance upward from their face, and have a transverse opening above to allow the wads to be forced out by the pressure of those below as the work progresses.

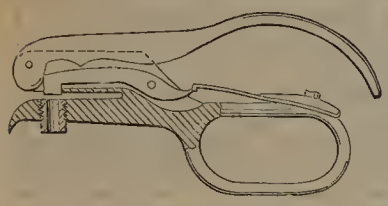
Those for cutting out irregular forms are made in a similar way. They are employed for cutting paper, cloth, etc., and are generally used with a screw press.

A punch for cutting mortises in sheet-metal is made of uniform width, but the ends are cut into a series of steps, by which the length of the mortise is extended as the steps successively take out a small piece at both ends at every cut, thus entailing but little risk of breaking the punch or bulging the metal. This is used in combination with a bolster having an aperture corresponding to it in length and width, and may be employed for forming mortises of any length up to the extreme length of the upper step.

Punch-pliers, having a conical punch with a hollow cylindrical aperture, are used by saddlers for cutting holes in leather; such punches are sometimes made oval for making elongated holes; they usually cut against a piece of copper in the other jaw of the pliers.

The conductor's or ticket-taker's punch is used for canceling checks, tickets, etc., on railroads, street-cars, at theaters, and other places. The punch proper may be of the shape of a cross, heart, star, diamond, crescent, circle, pentagon, etc., etc. One manufacturer has 74 varieties.

Fig. 4045.



Conductor's Punch.

In Fig. 4045 the cutter is pivoted to one handle and operated by a lever of the second class upon the other handle. A plate pushes the card off the cutter when the pressure is withdrawn.

A punch is used for indenting rasps. It has a peculiarly shaped point, and for a fine cabinet rasp is about 3½ inches long and ⅝ inch square at its widest part. The point has 4 facets: viewed in front, it shows an angle of 60°; in profile, 50°. Different sized punches are used for rasps of varying sizes. The teeth are so arranged in the rows, that each is intermediate between two preceding ones.

2. (*Type-making.*) A steel die (*e*, Fig. 4044) having one of the letters of the alphabet cut on its face, employed for making the intaglio impression in the copper matrix from which a type is cast. It is formed by hammering down the hollows and filing up the edges of the letter while the metal is in a softened state. Great care must be taken to form the set of punches required for producing a font so that faces of the letters may be of equal hight and uniform thickness. The steel is hardened after the letter is formed. See TYPE-FOUNDING.

3. (*Die-sinking.*) A hardened piece of steel having the design of the coin projecting from its face (*cameo*), and used to make indented impressions in the faces of *dies* for coining. See PLUG; DIE; MATRIX.

4. (*Hydraulic Engineering.*) An extension piece on the end of a pile, when the latter is beyond the stroke of the *monkey*. A *dolly*.

5. (*Carpentry.*) *a*. Studding used to support a roof. *b*. A tool for driving nail-heads below the surface.

6. (*Mining.*) A timber balk to support the roof of a gallery.

7. A stone-mason's chipping-tool.

8. (*Dentistry.*) An instrument to extract stumps of teeth.

See under the following heads: —

Belt-punch.	Punch and shears.
Button-hole punch.	Punching-bear.
Conductor's punch.	Punching-machine.
Duplex-punch.	Rail-punch.
Eyelet-punch.	Rasp-punch.
Gang-punch.	Screw-punch.
Hand-punch.	Sheet-metal punch.
Leather-punch.	Spring-punch.
Paper-punch.	Staple-punch.
Pinking-punch.	Wad-punch.
Pipe-slotting punch.	

Punch'eon. 1. (*Carpentry.*) *a*. A short post; a *stud* or *quarter* to support a beam at an intermediate point between *principals*.

b. The small quarters of a partition over the head of a door.

c. A slab of split timber, with the face adzed or smoothed with an axe. Used for flooring or bridge boards where sawed boards are inaccessible.

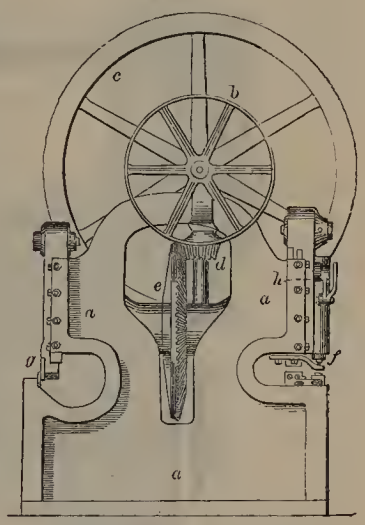
2. (*Coopering.*) A cask containing 84 or 120 gallons; the quantity varying in different countries and trades.

3. (*Stone-working.*) The punch of the marble-worker. An iron instrument with a sharp steel point. The *dog's-tooth* and *gradine* are marble-worker's punches.

4. A steel die, either in cameo or intaglio, with which impressions of objects or figures are stamped on metals and other substances, used in coining and other arts.

Punch'ing and Shear'ing Ma-chine'. (*Metal-working.*) A machine by which the operations of punching and shearing may be simultaneously effected. In that illustrated, the main frame *a a a* is made hollow; the pulley *b* is driven by belting, and is on the same shaft with the fly-wheel *e*.

Fig. 4046.



Punching and Shearing Machine.

Gears, one of which is shown at *d*, actuate the wheel *e* keyed on a shaft which operates two eccentrics, one actuating the punching slide *f*, and the other the shearing slide *g*, through the medium of connecting-rods. At *h* is a bar for lifting the punch without stopping the machine.

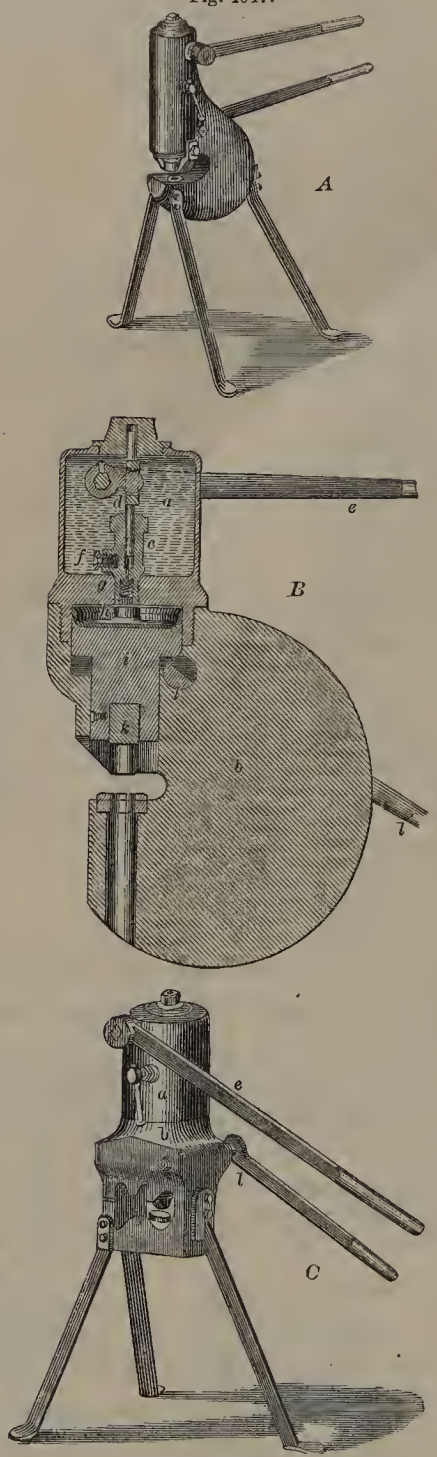
In the smallest machines of this kind the punching and shearing devices are on the same side. In the largest the driving-gear is somewhat differently arranged, but the operative mechanism is similar to the above.

Punch'ing-bear. A machine for making holes in sheet-metal, operated by simple lever power or by hydraulic pressure, after the manner of Bramah's press.

In Fig. 4047, *A* shows one of the latter kind, with an open mouth. *B* is a section on an enlarged scale. *a* is the cistern, screwed into the top of the solid iron block *b* and inclosing the pump *e*, which contains the plunger *d*, operated by the lever *e*; the upward movement of this lever causes water from the reservoir to enter the pump, passing through the wire-gauze covered inlet valve *f*, and its downward movement forces the water down past the spring-valve *g* into the chamber *h* over the head of the ram *i*, depressing the ram and punch *k* inserted therein. *l l* is a lever for raising the punch. *C* is a closed-mouth bear of similar internal construction, and is used for punching bolt-holes in railway rails for the reception of the bolts of fish-plates.

Punch'ing Buhl-work. Buhl-work is punched out by means of cutters inserted in the cavities of the upper one of two hinged plates, which are placed between the upper and lower beds of a press. The cutters may be made in any convenient number of pieces to form the pattern, so that if one be broken or injured it may be replaced by another. The inlay

Fig. 4047.



Hydraulic Punching-Bears.

and the piece into which it is inserted are successively cut out, each being perforated so as to perfectly correspond with the other. This process is well adapted for large works and where a large number of articles of the same pattern are to be made, but is not economical in other cases on account of the outlay required to produce the cutters.

Punch'ing-ma-chine'. The punching-machine is used for making the holes for rivets in boilers, tanks, flues, tubes, and other structures made of thick wrought-iron plates.

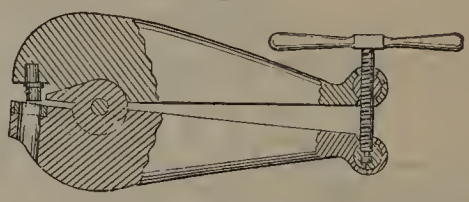
Its construction is necessarily of a strong and massive description, and as great force is to be exerted at short intervals, an equalizer must be provided, to avoid a shock or sudden diminution of velocity at each blow of the punch. This object is effected by means of a heavy fly-wheel, the momentum of which, while in motion, overcomes with comparative ease the resistance offered by the metal operated on, maintaining a nearly uniform speed and power.

In some machines of rather primitive construction, the punch is inserted in the shorter arm of a heavy lever, whose longer arm is raised by an eccentric on the fly-wheel shaft.

In more modern forms punching and shearing are generally effected by the same machine, the two operations being identical in principle; this result can be effected with but trifling modifications and additions to the appliances of the machine. See PUNCHING AND SHEARING MACHINE; PUNCHING-BEAR.

Fig. 4048 is a form in which the jaws are ap-

Fig. 4048.

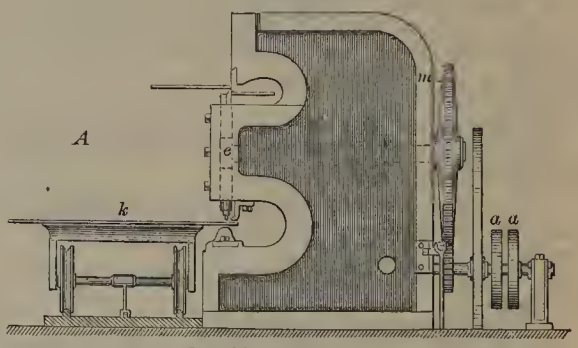


Punching-Apparatus.

proached by a screw operating at the tail ends of the lever jaws.

In the machine (*A*, Fig. 4049) for punching holes in boiler-plates, the plate is secured to the top of the movable table *k* by means of clamps, and the machine adjusted to the required distance between the rivet-holes. By the motion of the carriage, the plate is brought between the die and the punch; the latter is moved by an eccentric *e* on the axis of

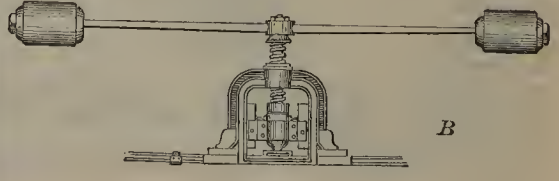
Fig 4049.



Punching Boiler-Plates.

the main spur-wheel, which is moved by the pinion on the driving-shaft on which are the fast and loose pulleys *a a*. The carriage receives an intermittent impulse by means of a rock-bar which is set in mo-

Fig. 4050.



Screw-Punch.

tion by a stud *m* projecting from the rim of the large spur-wheel.

B is a screw-punch with an oscillating weighted lever from 9 to 11 feet long to rotate the screw, which acts upon the end of the punch. A circular flange on the end of the screw is engaged by a collar-box on the upper end of the punch, so as to retract the same in the backward movement. The punch has a square shank which moves in the guide-socket.

Plates or bars should be punched *from* the *faying-surface*, that is, from the surface which is to touch that of the piece to which it is to be riveted. This is because the hole has a different diameter at the other side of the plate; the enlargement is favorable to the hold of the rivet when the above rule is observed.

The following table gives some data derived from experiment as to the pressures required for punching plates of copper, brass, and iron: —

Diameter of Punch.	Pressures.			Thickness of Sheet.	Pressures. Circ. hole 1 in. diam.		Iron.	
	Brass, .05 inch thick.	Copper, .15 inch thick.	Iron, .105 inch thick.		Copper.	Brass.	Thickness.	Pressure. Circ'r hole 1 in. diam.
In.	Lbs	Lbs.	Lbs.	In.	Lbs.	Lbs.	In.	Lbs.
1.5	8,475	15,996	23,273	.3	21,248	.....	.615	82,871
1.375	7,723	14,570	21,445	.205	15,542	.....	.565	76,962
1.25	6,980	13.275	19,682	.150	11,088	.....	.510	69,984
1.0	5,450	11,073	16,535	.100	7,461	.....	.445	62,591
.9	5,092	9,788	14,778	....	.....	.....	.404	57,623
.8	4,332	8,580	12,602	.050	3,646	.....	.358	51,382
.7	3,772	7,827	11,468	.045	3,362	5,448	.283	40,486
.6	3,267	6,706	9,772	.041	.....	4,997	.245	35,712
.5	2,635	5,507	7,916	.034	2,538	3,730	.183	27,978
.4	2,183	4,585	6,660	.032	2,212	3,540	.145	22,213
.3	1,673	3,435	4,970	.028	.....	2,964	.104	16,533
.2	1,110	2,240	3,333	.022	1,544	2,448	.057	9,452

These amounts may vary somewhat according to the quality of the metals. A general rule for wrought-iron is that about 50,000 lbs. pressure is required for punching a circular hole 1 inch in diameter through a plate $\frac{1}{4}$ of an inch thick, and that this force varies in direct proportion to the area of the hole and the thickness of the metal Thus, to punch a hole of $\frac{1}{2}$ inch diameter through iron $\frac{1}{16}$ inch thick would require but $\frac{1}{8}$ the above pressure

Keir's punches for red-hot iron are made of chilled iron, whose temper does not draw, like steel. The punches are fixed in cast-iron sockets, from which they only project sufficiently to perforate the wheel-tires, in the formation of which they are used.

The diameter of the punch for thick plates should be about $\frac{3}{16}$ inch less than the die; for thinner plates $\frac{1}{4}$, or even $\frac{1}{16}$, of an inch less. Upon the amount of this difference depends the degree of taper in the hole, for the side on which the punch enters will correspond with the size of the punch, while the lower portion of the piece forced out of the plate will correspond with the hole in the die, thus making a tapered hole. This peculiarity, if carefully attended to, may be made available to a useful end, by giving the rivet, when compressed into the hole, the form of a double cone; and great care should be taken to punch the hole from the inside, or the side next the plate to which it is to be riveted, that the taper in the hole may be in the direction favorable for the rivet.

Punch-pli'ers. One jaw of this tool has a hollow punch, and the other forms a flat die against which the punch operates. They are used by shoemakers, conductors on railroad and street cars, and generally for mutilating tickets to prevent their being used a second time.

Pun'gy. A small sloop or shallop or a large boat with sails.

Pun'jum. (*Fabric.*) A fine, heavy, unbleached cotton long-cloth made in India.

Pun'kah. A large broad fan suspended from the ceiling, or a number of such fans acting simultaneously and worked by an attendant.

It is common in India, being suspended over a table or bed or in any other apartment. It has a line attached to one end, which passes through the wall or door to an attendant on the porch outside In some of the houses of the European residents and princes of India, the *punkah* is worked day and night, the servant shifting his attendance as the *sahib* moves from room to room, — from his study, dining-room, or bedroom.

The Nabob of Oude, some years since, when there was such a thing, imported a steam-engine from England to work the *punkahs* of his palace.

Punt. A small flat-bottomed boat, usually with square ends. It is not adapted for speed, but is used in ducking, or in calking or painting vessels afloat.

Pun'ty. (*Glass.*) A *ponty*. A glass-maker's iron rod, by which he manipulates the glass. *Pontil.*

Puoy. A spiked pole used in propelling a barge or boat.

One with a cap to prevent its sticking in the mud is called a *quant.*

Pu'pil, Ar'ti-fi'cial. (*Surgical.*) *a.* An opening made for the passage of rays of light by the removal of a portion of the iris. The operation is to obviate the effect of opacity of the lens, or adhesion or permanent contraction of the iris. The operation is *iridectomy.*

b. Artificial pupil is formed also by simply dislocating the natural pupil. The iris is drawn out through a small incision, and a piece of it tied off by fine *ligature;* the ligatured piece of iris *sloughs* off in a few days, and the pupil remains in its new position. *Irido-desis.*

c. The operation is also formed by dividing with scissors the iris by two incisions, diverging from each other, the loosened triangular-shaped flaps of iris being left to shrivel up.

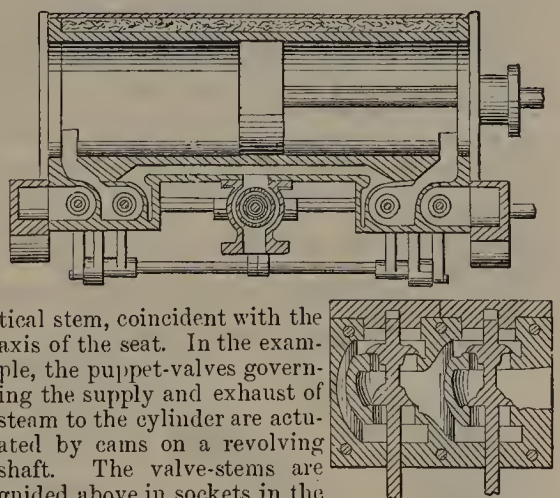
Pup'pet. 1. (*Turning.*) A standard rising vertically from the bed or shears of a lathe and holding the *centers* on which the work is placed to revolve. In the ordinary lathe the head-stock has also a mandrel and grooved wheel to which motion is imparted by a band. The *puppets* are also known as *head* and *tail stocks.*

2. A disk-valve having a stem and vertical motion to and from its seat.

Pup'pet-head. Of a lathe or boring-machine. A sliding device on the upper part of the bed; it holds the back center, and may be fixed at any required distance from the front center.

Pup'pet-valve. A valve which moves vertically and is guided to and from its seat by a central vertical stem, coincident with the axis of the seat. In the example, the puppet-valves governing the supply and exhaust of steam to the cylinder are actuated by cams on a revolving shaft. The valve-stems are guided above in sockets in the top plates of the valve-chests, and by removing these plates the valves may be reached or removed.

Fig. 4051.



Puppet-Valves.

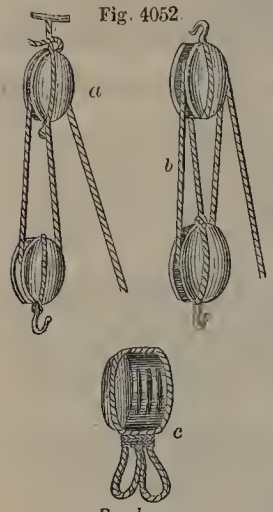
Pur'chase. A mechanical power to increase the power applied. The names are various; some indicate a difference in character, others merely in application. Among them are: *whip, whip-upon-whip, luff-tackle, luff-upon-luff, runner, double-runner, barton, jeer, viol, gun-tackle;* as well as *winch, gin,*

jack, *derrick*, *crab*, *capstan*, *windlass*, etc. See HOISTING; BLOCK; TACKLE; PULLEY.

A *single purchase* is one in which a rope reeves through a single fixed block. It merely changes the direction of the rope. See WHIP.

A *double purchase* (*a*) or *double whip* is made by reeving a rope through a single block, then through another single block, and making the end fast to the one it was first rove through.

Fig. 4052.



Purchases.

When used as a *gun-tackle purchase*, the *standing-block a* is made fast to a ring-bolt on the cheek of the gun-port, and the hook of the *running-block* is connected to an eye on one of the cheeks of the gun-carriage. By the *purchase* the gun is run out, and by similar means is run in when required.

The *threefold* or *luff-tackle purchase* (*b*) is composed of double and single blocks, and is used for many purposes on board ship.

A luff-tackle applied to the fall of another luff-tackle is called *luff-upon-luff*.

Pur'chase-block. (*Nautical.*) A double-strapped block (*c*) having two scores in the shell for that purpose; the strap is wormed, parceled, served, and spliced together. It is then doubled so as to bring the splice at the bottom of the block.

Pur'dah. (*Fabric.*) An Indian blue and white striped cotton cloth.

Pure. (*Leather Manufacture.*) The *bating*-bath, consisting of a solution of dogs' and birds' dung, used to counteract the action of the lime used in unhairing.

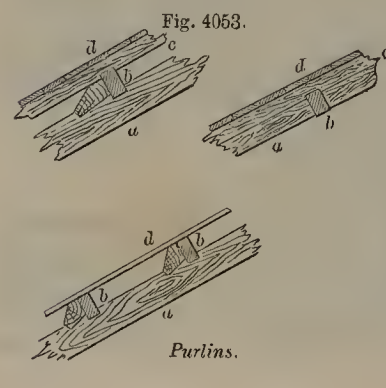
Pur'ger-y. (*Sugar.*) The portion of a sugar-house where the sugar from the coolers is placed in hogsheads or in cones, and allowed to drain off its molasses or imperfectly crystallized cane-juice. It is generally one of the wings of the plantation sugar-house, in the bottom of which, in place of a floor, is a hydraulic cement cistern about four feet deep. Over this cistern are laid strong timbers, on which the hogsheads or cones rest while they are being filled from the coolers. At the bottom of the hogsheads are holes through which the molasses drains into the cistern.

Purg'ing-cock. (*Steam.*) The mud-cock or discharge-valve of a steam-boiler.

Purl. A gold or silver wire, formed into a spiral, used in lace work.

Pur'lin. (*Carpentry.*) A horizontal timber resting on a *principal rafter*, or a *purlin-post*, which is stepped into the *tie-beam*, and helps support the *rafters* of the roof. (See KING-POST TRUSS.)

Fig. 4053.



Purlins.

In the cut: —

a, principal rafter.
b, purlin.
c, common rafter
d, sheathing or slate-boarding

Purlins are also known as *side-timbers* or *side-wavers*.

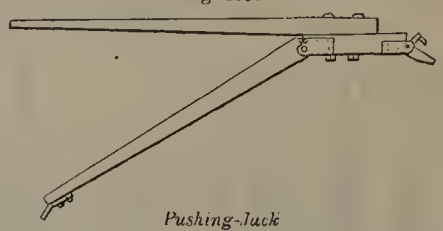
Pur'lin-post. A strut supporting a *purlin*, which is a longitudinal plate beneath the rafters, to prevent their sagging.

Push'er. A form of *bobbin-net machine*, so called from having independent *pushers* to propel the bobbins and carriages from front to back, instead of pulling or hooking them, as in other arrangements.

Push-hole. (*Glass-making.*) A hole in the flattening-furnace for annealing and flattening plate-glass.

Push'ing-jack. One for moving a railway-car or other object through a small distance. The example is a toggle bar; one end is placed against a tie, and the upper end against the car, and the latter moved by depression of the lever.

Fig. 4054

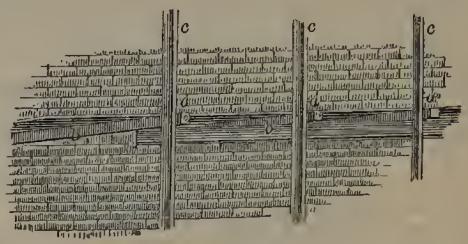


Pushing-Jack

Put'logs. The transverse pieces *a a* in a scaffolding which rest in holes in the wall at one end, and on the *ledgers b* at the other end. The ledgers are fastened or lashed to the scaffold poles.

The holes for the *putlogs* are yet visible in the Pont du Garde erected by the Romans in Gaul. They are called *columbaria* by Vitruvius, from their resemblance to nests in dovecots.

Fig. 4055.



Putlogs.

Put'tock-shrouds. (*Nautical.*) The short shrouds which lead from the lower shrouds to the top. See FUTTOCK-SHROUDS.

Put'ty. 1. (*Glazing.*) A composition of pounded whiting and linseed-oil, beaten up into a tough, tenacious cement.

It is used for securing window-panes in sash, in stopping (*badigeon*) crevices in wood-work which is to be painted, and for various other work for which its present plasticity and future hardness adapt it. Some trades employ glue-putty, in which hot melted glue is substituted for the oil.

2. (*Plastering.*) A fine mortar, nearly all lime, used in stopping crevices of shrinkage.

Put'ty-knife. A knife with a short lanceolate blade, used for spreading putty.

It is sometimes called a *stopping*-knife.

The knife used by glaziers for removing old putty has a single edge, a stout back, and a nearly square end. It is driven by a hammer, and is called a *hacking-out* knife.

Put'ty-pow'der. An oxide of tin, or of tin and

lead mixed in various proportions, used as polishing powder by opticians and lapidaries.

It is prepared by oxidiziug the metal in a closed iron box having a perforation iu front, which is surrounded by the fire and maintaiued at a red heat, the metal being constantly stirred to expose all portions of it to the air; when entirely oxidized it is removed from the box, the lumps of oxide are selected from the mass and ground, the powder being afterward sifted. The whitest powder, if heavy, is the purest. Inferior kinds are brown or yellow; others, having a small quantity of ivory-black intermixed, are known as *gray putty*. Pure white putty, used by marble-workers, opticians, etc., is the smoothest and most cutting: it should consist of oxide of lead aloue; but to lessen the difficulty of manufacture, a little lead (the linings of tea-chests) or of an alloy called *schruff* (prepared by the pewterers) is added to assist oxidation.

Putty-powder of fair commercial quality is prepared from equal parts of tin and lead. A commou dark-colored powder is prepared from lead alone, but is much inferior in quality.

Putty-powder for fine optical uses may be prepared by dissolving tin in nitro-muriatic acid, filtering the solution, and precipitating the peroxide thus formed with liquid ammonia; the precipitate is washed with water, collected on a cloth filter, dried and pressed so as to form a lump, which is broken iuto pieces and, after farther drying, levigated on a glass plate with an iron spatula, and subjected in a crucible to a low white heat. The powder is then washed or elutriated to remove the coarser particles. This process is due to Mr. Ross.

Puz'zle. A contrivance for affording amusement and exercising the ingenuity by taking apart a set of connected devices, combining a number of separate pieces so as to produce one or more figures, finding the mode of entry in or egress from a space inclosed by a complicated series of lines, etc., etc. Sometimes the puzzle consists of a miniature ship or other device inclosed within an object which has no opening of sufficient size to admit the passage of the inclosure. Of this class are the Chinese puzzles, consisting of a series of balls one within the other, and all apparently carved out of a single piece.

The familiar toy, "puzzle-rings," sold in the stores and on railroad-cars, — in which the ingenuity consists iu getting the rings on and off a link, — engaged the pen and attention of Cardan in the sixteenth century; and the celebrated mathematician and philosopher, Dr. Wallis, has given a clear and elaborate description of the same instrument in the second volume of his works, under the title of "Complicati Annuli," or puzzling-rings.

Puz'zle-lock. A lock of the letter or dial kind, which can only be opened when a hand is caused to point to a certain figure or figures on one or more dials, or particular letters, out of a number engraved on a series of rings, are brought into a certain position with respect to one another. The puzzle consists in finding the proper combination, which can only be done, if at all, by one unacquainted with the secret, after repeated trials. A *letter-lock*.

Puz'zo-la'no; Puoz'zo-la'no. See POZZUOLANA.

Pyc'no-style. (*Architecture.*) Having the distance between the columns 1½ times their diameter.

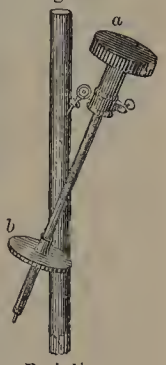
Pyr-he'li-om'e-ter. An instrument invented by Pouillet for measuring the amount of heat radiated from the sun.

It consists of a shallow cylinder *a* of very thin copper or silver on a stem, provided with means of attachment to a stationary object, and carrying a disk *b* on which the shadow of *a* may be received, so that it may be pointed directly toward the sun.

The cylinder is blackened in order to absorb all the heat possible, and is filled with water in which the bulb of a thermometer is placed. The instrument, at the atmospheric temperature, is first shaded from the sun, but exposed to the sky for five minutes, and, the difference of temperature noted, the shading screen is then withdrawn, and the cylinder exposed to the direct action of the sun's rays for five minutes, and the temperature noted, when it is again shaded for five minutes, and the fall of the thermometer observed.

The formula $T + \frac{\theta + \theta'}{2}$ indicates the amount of heat received from the sun; θ being the difference of temperature due to exposure to the clear sky, T the increase on exposure to the sun, and θ' the fall in five minutes after being again shaded. To obtain the amount of heat actually radiated by the sun, that absorbed by the atmosphere must be added. This is roughly determined by observations when the sun is at different altitudes, so that his rays have to traverse different thicknesses of air. An *actinometer*.

Fig. 4056.



Pyrheliometer.

Py-rog'ra-phy. A mode of printing by a system of heated metallic cylinders, which burn into the wood any design required. A mode of CARVING (see page 492).

Py-rom'e-ter. "Fire-measurer." An instrument for indicating temperatures above the boiling-point of mercury, 660° Fah. It was first employed by Muschenbroek in the form of a simple metallic bar, about 1730.

The first which ever came into extensive use was that of Wedgwood, about 1780; it was devised and used by him for testing the heat of his pottery and porcelain kilns.

No fewer than eleven different modes have been proposed or actually employed for measuring high temperatures.

1. By contraction, as in Wedgwood's.
2. " expansion.
3. " change of pressure in confined gases.
4. " the amount of heat imparted to a cold mass.
5. " fusing-point of solids.
6. " conduction and radiation of heat.
7. " color, as red and white heat.
8. " change in velocity of sound.
9. " resolution of chemical compounds.
10. " generation of electricity.
11. " change in resistance to electricity.

Of these methods the first was formerly extensively used, but is now generally conceded to be unreliable. The second has been considerably employed, but presents difficulties in its applications to practical use, especially where great delicacy is required. The third is reliable in those cases where it can be practically applied, but its principal use is as a standard of comparison for pyrometers constructed on other principles. The fourth, on account of the care and skill necessary to attain a correct result, is not generally available. The fifth is only available within certain limits. The sixth does not give satisfactory results. The seventh, though of great importance as indicating the proper heat for working and tempering metals, gives but a rude approximation to their actual temperature. The eighth, depending on the change of pitch in musical tones, is obviously not calculated for general use. The ninth and tenth methods are, in the present state of science, practically unavailable for common use. The eleventh, adopted by Siemens, appears better than any other to fulfill the conditions required in practice; his instrument is described farther on.

1. Wedgwood's pyrometer was of the first class. Its operation depends on the property of clay to contract on exposure to heat. The apparatus is very simple, consisting of a gage, by which the dimensions of the clay, made into small cylinders, are measured before and after its subjection to heat. The indications of the instrument are found to be very unreliable, owing, among other causes, to the fact that clay may contract when subjected to a comparatively moderate heat for a long time as much as when exposed to more intense heat of shorter duration.

2. The pyrometer *A* (Fig. 4058) is of the second class. One end of the bar is fixed in the post, and the other end is free to

move as the rod is expanded by the heat of the burning alcohol below it, the degree of expansion being marked by the pointer on the quadrant-index. Bars of different metals, but of the same size, being exposed for the same length of time to the flames, their relative increase of length under a given degree of heat is determined.

The mercurial thermometer has been used for temperatures up to 780° Fah., by filling the tube above the column with air under a pressure of four atmospheres.

Daniel's pyrometer has a platinum bar inclosed in a black-lead tube, closed at the bottom. When exposed to heat, the platinum expands more than the inclosing cell, and projecting upward moves a lever, which drives forward an index upon a graduated arc.

Achard proposed using a ball and tube of semi-transparent porcelain, highly baked, containing a fusible alloy of bismuth, 1; lead, 1; tin, 1. In the temperature of the air this remains solid in the tube, but becomes fluid about 212° Fah. Its expansion by increment of heat is visible within the graduated tube, and the temperature is thereby indicated.

Bréguet's pyrometer consists of two thin strips of gold and platinum or silver and platinum soldered together, the compound strip being bent into a helix for portability and concentration. The upper end is fixed, and to the lower end is attached a horizontal index. Change of temperature in the surrounding air changes the length of one side of the compound strip more than the other, and the helix twists or untwists through an angle very nearly proportional to the change of temperature. This is on the principle of the compensation-balance.

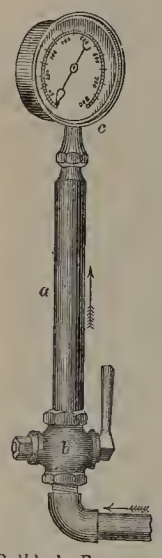
The pyrometers generally employed in England are sticks of lead or zinc. These are only available up to temperatures approaching the fusing points of those metals.

Gauntlett's pyrometer has a stem composed of tubes of refractory clay, inclosed in an iron stem 3 feet long. This is employed for temperatures of 1000° to 1200° Fah. A brass stem 4 feet long, inclosing an iron rod, is used for temperatures below 800° Fah. In either, the degree of heat is indicated by the difference of the expansions of the two materials, the rate of which is known. Gauntlett's can only be depended on up to about 850°, as above this the copper rod employed does not contract to its original length on cooling. Krauss's, which depends on the expansion and contraction of a palladium spring, can only be trusted up to about 1000°.

The pyrometer for ascertaining the temperature in the flues of boilers consists of an iron rod fixed at the back of the flue, and connecting at front to a lever whose oscillations indicate the expansion and contraction of the rod by heat.

Bulkley's blast-furnace pyrometer (Fig. 4057) has an upright tube *a* with perforations near its upper end, connected with the blast-pipe of the furnace, and provided with a valve *b*. A copper expansion-rod is inclosed within the tube and connected with the index of a dial *c*. On opening the valve the hot air from the blast-pipe enters the tube *a* and escapes through the perforations, expanding the copper rod, which indicates the temperature on the dial.

Fig. 4057.



Bulkley's Pyrometer.

The valve is opened only when it is desired to ascertain the temperature, saving the expansion-rod from the distortion occasioned by constant exposure to heat, which soon affects the correctness of its indications.

3. M. Lamy devised a means of ascertaining the temperature of furnaces up to red heat by measuring the tension of carbonic-acid gas developed from marble when heated; it has an indicating apparatus which may be placed at a distance from the meter, so that those from a number of kilns or furnaces may be brought together directly under the eye of the superintendent. This instrument is of the third class.

4. In Siemens's instrument of the fourth class the temperature is inferred from the heat imparted to a pint of water inclosed in a copper vessel, by a ball of copper or iron weighing $\frac{1}{50}$ part as much as the water; this should raise the temperature of the water 1° for every 50° of heat in the ball.

5. See ALLOYS.

6. Depends upon observations with thermometers of moderate range, at relative distances. See PYROSCOPE.

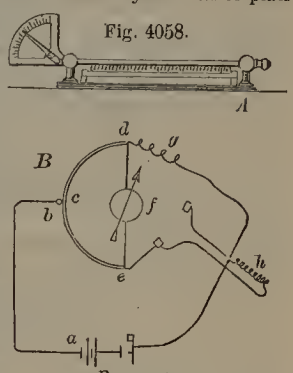
7. The workman's test by observation.

8, 9. Laboratory tests.

10. Becquerel devised a thermo-electric pyrometer of the tenth class, consisting of two wires of platinum and palladium of equal length connected together at one end, their other ends being connected to the binding screws of a galvanometer. The palladium tube is passed through a tube of porcelain, and this, with the platinum wire, is introduced into a larger porcelain tube, which is exposed to the heat of the furnace. A scale of temperatures corresponding to the intensities of the electric currents developed was constructed by comparison with an air pyrometer, each division of the scale corresponding to 10° Centigrade.

11. Siemens invented a pyrometer of the eleventh class, depending on the increased resistance offered by an iron or platinum wire to the passage of electricity. This may be adapted to measuring either high or low temperatures, and was used by Dr. Carpenter for ascertaining the temperature at great depths in the Atlantic Ocean. That for high temperatures (*B*, Fig. 4058) consists of a coil of fine platinum wire, about 3 yards in length, wound around the circumference of a grooved clay cylinder. The ends of the coil are connected with two thicker platinum wires, which are in turn connected with copper conducting-wires; the whole are protected by clay pipes and inclosed in an iron tube. The end at which is the platinum spiral is closed, and the other end is provided with a wooden cap containing two contact screws connected with the battery wires, thus including the spiral in the circuit.

Fig. 4058.



Pyrometers.

For temperatures above the melting-point of iron, this end of the tube is made of platinum; and a part between the spiral and outer end of the tube is made much thicker than the rest, in order to prevent too rapid cooling, which would impair the accuracy of the indications.

When the closed end is pushed into a furnace, the coil becomes heated, and its conductivity is diminished. The amount of diminution is measured by a galvanometer in the following manner. The current from the zinc-pole *a* of the battery goes to the movable contact-wheel *b*, which may be adjusted to any part of the platinum arc *c* on the edge of a disk of ebonite. When the wheel is in the position represented, the current is divided, one part passing to *d*, and the other to *e*; midway between these points the galvanometer *f* is fixed; from the two ends of the platinum wire the current on one side passes into the constant resistance *g* and into the galvanometer; on the other side it passes into the other terminal of the galvanometer, and at the same time into one of the leading wires of the spiral *h*. The currents passing respectively through the spiral and the resistance meet at a given point in their passage to the other pole of the battery.

So long as the electric forces at *d* and *e* are equal, the galvanometer needle remains at rest, but when their relations are disturbed, the needle is deflected; the balance may, however, be restored, and the needle brought back to zero by the movement of the wheel *b*, the position of which, on the arc *c*, indicates the degree of heat.

For reading, the astatic galvanometer needle is brought to zero of its scale; on pressing the contact key *k*, the circuit is closed, deflecting the needle; the wheel *b* is then moved until the needle is again brought back to zero and the reading on the arc noted.

Many of these instruments register up to 1000° Centigrade (2218 Fah.), and they are sometimes constructed to indicate double this temperature.

Pyr'o-phone. A musical instrument, invented by M. Kastner, in which the various notes are produced by the burning of hydrogen gas within glass tubes of various sizes and lengths. Its principle depends on the fact that if two or more separate flames are placed at a distance from the base of the tube equal to one third its hight, uniform vibrations will be produced, which cease when the flames are brought together. These results are effected by attaching to the pipes conveying the gas collars connected to rods operated by a series of keys arranged like those of an organ, by which the flames, normally in contact, are separated when it is desired to emit a note.

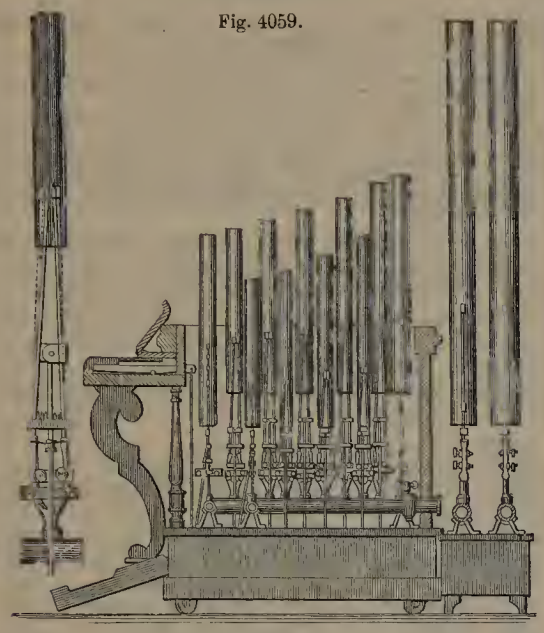
Py-roph'o-rus. Mechanically considered, an apparatus for kindling fire. See also ELECTROPHORUS.

Chemically considered, a substance which takes fire when exposed to the air.

Homberg's pyrophorus depends upon the heat spontaneously developed by the association of alum, sugar, and flour.

Brande recommends a mixture of equal parts of alum and brown sugar stirred over a fire in an iron ladle till quite dry. It is then put into an earthen or coated glass bottle, and heated red-hot so long as a flame appears at the mouth. It is then removed, carefully stopped, and allowed to cool. The

Fig. 4059.



Pyrophone.

black powder which it contains becomes glowing hot when exposed to air. The experiment succeeds best in a damp state of the air, and may be accelerated by breathing upon the powder.

Two other recipes are given by Brande:—

Mix 3 parts of lampblack, 8 parts of carbonate of potassa, 4 parts of dried alum. Calcine as before.

Or, 27 parts of sulphate of potassa, 15 parts of calcined lampblack. Heat to redness in a crucible, and keep in a stoppered bottle.

Or, heat tartrate of lead red-hot in a glass tube and seal hermetically. Break the tube and shake out the powder, which inflames spontaneously by contact with the air.

See Cooley's "Cyclopædia," page 1084.

A pyrophorus for cigars is described as follows: Neutral sulphate of iron is treated with diluted nitric acid and precipitated; the resulting oxide is reduced by heat in a tube through which a current of hydrogen is passed. This is combined with a sulphide of aluminium and potassium and a small amount of carbon. A portion of this is placed on the end of a cigar, the breath is inhaled, and by the affinity of certain particles of the composition for oxygen the iron is heated and the cigar lighted.

Pyr'o-pho-tog'ra-phy. A term including those processes in the photographic art in which the heat of a furnace is used to fix the picture. Enamel photography.

The picture copied must be on some transparent substance, or, if on paper, must be made transparent by the application of oil. The glass plate is covered with a coating of a certain gummy compound, which becomes hard under the action of light. The impression, when taken, is brought out by the application of a flux, and by heating the plate to a white heat is made permanent.

Pyr'o-scope. An instrument, invented by Leslie, to measure the intensity of heat radiating from a hot body or the frigorific influence of a cold body. The instrument is like a differential thermometer, one ball being covered with thick silver-leaf; the other ball is naked and forms the pyroscope.

Pyr'o-ster'e-o-type. A process in which a block of wood is prepared as a matrix for a fusible metal by burning away portions of its surface. The burning-tool is a delicate blade heated by a jet of flame, and is thrust down into the wood, making an incision of a given depth. A cast is then taken in type-metal; the lines being salient afford a printing surface.

Pyr'o-tech'nics. Preparations of inflammable material are used in making cascades of fire or explosions for signals or as expressions of rejoicing.

Fire-works are of Oriental origin. The Chinese and Japanese still excel in their production. The "Yokobama Herald" describes the effects produced at an exhibition of Japanese daylight fire-works These consisted principally of bombs which, exploding high in the air, discharged variously colored jets of smoke, and sometimes large parachutes which assumed the figures of fishes, snakes, or birds, which hovered kite-like and motionless in the air for an incredibly long time. Occasionally they took the shape of cottages, temples, human beings, trees, and flowers, and various other forms. The smoke figures were, however, the most amusing. One of those most frequently attempted was a cuttle-fish, with a body of thick black smoke, and arms of lighter hues. Though the smoke was soon dissipated by the wind, the resemblance for a few moments was very striking.

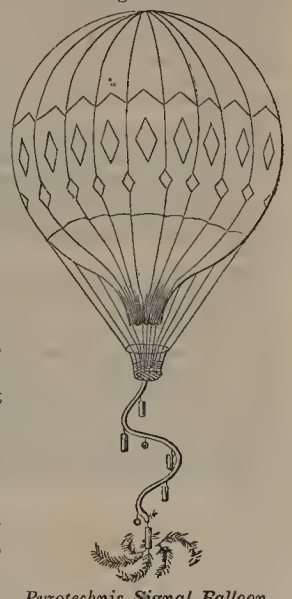
Our artificers do not possess the secret of making fire-works such as these, their efforts being confined to the production of variously colored fires for exhibition at night. The basis for nearly all pyrotechnic compositions consists of nitre, sulphur, and charcoal in varied proportions pulverized and mixed with some material which imparts color to the flame. The nitrate of strontia produces a red light; nitrate of soda, yellow; sulphate of copper, blue; nitrate of baryta, green. Steel, iron, copper, and zinc filings are used for producing brilliant sparks of various colors.

Besides these, numerous other substances are used for producing different tints, most of which may be found in works on pyrotechny, though many artists in this line claim to have secret compounds or processes for producing peculiarly brilliant flames. The compositions are formed into small pieces called stars, for insertion in rockets and bombs, or are driven into paper cases which are attached to light frameworks of wood or bamboo for stationary fire-works. See under the following heads:

Automatic fire.
Bengal-light.
Blazing-comet.
Blue-light.
Brilliant.
Carcass.
Cascade.
Catherine-wheel.
Chinese fire.
Colored fire.
Cougreve-rocket.
Cracker.
Detonating-powder.
Fire-ball.
Fixed star.
Fixed sun.
Fulminating-powder.
Fuse.
Gold-rain.
Greek fire.
Incendiary compound.
Incendiary shell.
Lance.
Leader.
Light-ball
Marron.
Match.
Mosaic.
Palm-tree.
Pitched fascine.
Portfire.
Quick-match.
Revolving sun.
Rocket.
Rock-fire.
Roman candle.
Serpent.
Shell.
Shower.
Signal-rocket.
Silver-rain.
Slow-match.
Squib.
Star.
Stink-ball.
Sun-case.
Tarred link.
Tourbillon.
Wheel-case.

Pyr'o-tech'nic Bal-loon'. One for carrying aloft pyrotechnic signals.

Fig. 4060.



Pyrotechnic Signal-Balloon.

Py-rox'y-line. From *πυρός* (fire) and *ξύλον* (wood). Gun-cotton. An explosive obtained by immersing vegetable fiber in nitric and sulphuric acids and subsequent drying. Invented by Schonbein, 1846. See GUN-COTTON.

Gun-cotton dissolved in ether or chloroform forms *collodion*, and when this is evaporated a horny material is the result. This is used for many purposes and in various combinations, as a scale to protect objects, in combination with gums, resins, vegetable fiber, bone-dust, asbestus, etc.

It is used as a substitute for hard rubber, as an artificial horn or ivory, a composition for knife and tool handles, for dental plates, veneers, buttons; liquid, as a varnish or size.

Hyatt's process for obviating the difficulties attending the production of articles made of pyroxyline by pressing in porous molds consists in subjecting the articles to pressure in close vessels for a certain length of time; compressed air is preferred as the medium for effecting the pressure, on account of economy and the rapidity with which it removes the solvent. The article, after being molded or coated with the compound, is placed in a receiver and subjected to a pressure of twelve atmospheres; a greater pressure may, however, be employed without injuring the material The receiver has an aperture for removing the vapor-charged air; the time occupied in absorbing the moisture from the material depends on the amount of air passed through the receiver; usually it is ready for removal to the drying-chamber in about 36 hours.

In the process of Deitz and Wayne, ramie fiber is employed; this is treated in a manner similar to cotton.

A smaller quantity of solvent is required for making collodion from this fiber than from cotton, the proportions being about 3 pounds of ether and 12 fluid ounces of alcohol to each pound of prepared ramie. By the addition of 2 to 10 per cent of gum sandarach (dissolved) and 15 per cent of castor oil, the compound is rendered more elastic and less subject to shrinkage in drying. The substances are thoroughly incorporated by grinding, colored with any suitable pigment, if desired, and evaporated to proper consistency for molding.

Pierson combines with mineral and vegetable substances; uses for moldings. He also uses it to render woven goods air and water tight.

English patent 533 of 1868 makes dental plates by combining with shellac; grinding, moistening with solvent, and molding by pressure.

McClelland, 1869, also makes dental plates.

Streeter, 1869, applies it as a veneer to dental plates; molds by heat and pressure.

Hunt, 1874; Newton, 1872; Pursell, 1872; Troutman, 1871, refer to the use of pyroxyline with dental plates, for attaching teeth.

Hill, 1869, combines with coloring-matter and asbestus; covers layers of cotton, felt, woolen, wire gauze, etc.

McClelland, 1868, adds gum-copal, coloring-matter, and phosphate of ammonia. Dry by gentle heat, pulverize.

Seeley, 1868, adds nitro-glucose to gun-cotton in solution.

Hyatt, 1869, adds ivory-dust, bone-dust, paper, flock, or asbestus. Heat, press, and evaporate solvent.

Spill, 1869, protects insulated telegraph-wires. Uses a compound of xyloidine, oil-camphor, gutta-percha, and pigments.

Hyatt, July 12, 1870, grinds pyroxyline into a pulp, mixes it with finely comminuted gum-camphor, dissolves the components by heat, and continues the pressure upon the mold until the contents are cooled.

McClelland, July 22, 1870; a mode of coating articles with collodion compounds by molding it upon them in flasks or shells.

Hyatt and Hyatt, March 28, 1871, describe the making dental plates of pyroxyline dissolved in camphor (celluloid) by means of heat, and then molded to form while in a plastic state.

Brockway, April 18, 1871 (No. 113,735), is for compressing, straining, and molding plastic pyroxyline. No. 113,736 is for a dental plate of pyroxyline, made by first forming the sheet by molding it, then boarding, pressing, and shrinking it.

Winsborough, April 25, 1871, bleaches pyroxyline by chlorine, to render it transparent. He also introduces camphorated pyroxyline into the molds, and then expels the camphor or other solvent by heat or chemical means.

Hyatt, May 16, 1871, describes a mode of holding centrally in a mold articles to be coated

Troutman, October 17, 1871, describes a mode of attaching artificial teeth to the base by solid pieces of the same material as the base.

Hyatt and Hyatt, December 5, 1871, describe and exhibit an apparatus for molding dental plates, consisting of a flask press and an oil bath, heated by a lamp.

Newton, April 23, 1872, describes a mode of attaching pyroxyline backing to artificial teeth, by softening, shaping, and puncturing the backing, and then pressing it upon the pins of the teeth.

Pursell, May 7, 1872, describes a flask, clamping-attachment, and case, forming an apparatus for attaching artificial teeth to the pyroxyline base.

Hyatt and Hyatt, November 19, 1872, describe process and apparatus for manufacturing celluloid. The mixture of pyroxyline and gum-camphor is pressed into cakes and then pressed in a pile with alternating layers of paper. The combined materials are pressed by a plunger in a heated cylinder, dissolved, and discharged at a nozzle in a continuous rod or sheet.

Jones, March 11, 1873, makes truss-pads of pyroxyline.

Hyatt, April 29, 1873, has a means of subjecting newly coated articles to pressure, which absorbs the solvent, but does not allow expansion of the coating or formation of air-cells.

McClelland, October 21, 1873, describes modes of removing the solvents from xyloidine and pyroxyline compounds.

Smith, May 12, 1874, makes an artificial coral.

Hyatt and Hyatt, October 27, 1874 (No. 156,352) dissolve the pyroxyline in camphor and alcohol, which remains latent till heat is applied; (No. 156,353) apply mastication previous to heating and converting; (No. 156,354) make factitious ivory by combining ivory or bone-dust, pyroxyline, powdered camphor, and nitric ether.

When gun-cotton or pyroxyline is heated with powdered gum-camphor it is dissolved, and this material, under the name of *celluloid*, is extensively used as a substitute for hard rubber for combs, billiard-balls, dominos, knife-handles, dental plates, truss-pads, coating metallic articles, and for the manufacture of imitation coral, ivory, tortoise-shell, horn, and the like.

See the following United States patents: —

65,267.	Pierson	1867.	105,338.	Hyatt	1870.
79,261.	Seely	1868.	105,823.	McClelland	1870.
77,304.	McClelland	1868.	113,055.	Hyatt *et al.*	1871.
90,765.	McClelland	1869.	114,945.	Hyatt	1871.
90,766.	McClelland	1869.	121,522.	Hyatt	1871.
96,132.	McClelland	1869.	113,272.	Dietz *et al.*	1871.
3,777.	McClelland	1869.	114,242.	Winsborough	1871
3,778.	McClelland	1869.	120,130.	Troutman	1871.
88,228.	Streeter	1869.	113,735.	Brockway	1871.
88,229.	Streeter	1869.	113,736.	Brockway	1871.
88,260.	Strecter	1869.	125,979.	Newton	1872.
89,253.	Strecter	1869.	126,575.	Pursell	1872.
89,254.	Streeter	1869.	133,229.	Hyatt	1872.
93,086.	Hill	1869.	133,969.	Dietz *et al.*	1872.
88,633.	Hyatt	1869.	138,254.	Hyatt	1873.
88,634.	Hyatt	1869.	143,772.	McClelland	1873.
89,582.	Hyatt & Blake	1869.	136,735.	Jones	1873.
91,341.	Hyatt & Blake	1869.	150,722.	Smith	1874.
91 377.	Spill	1869.	156,352.	Hyatt	1874.
91,378.	Spill	1869.	156,353.	Hyatt	1874.
97,454.	Spill	1869.	156,354.	Hyatt	1874.
91,393.	Whitehouse	1869.	153,196.	Hunt	1874.

English patents: —

2,359	of 1855.	2,666	of 1867.
653	of 1857.	536	of 1868.
2,740	of 1859.	3,984	of 1868.
2,249	of 1860.	3,102	of 1869.
1,129	of 1867.		

Pyx. A box. The word is derived from the Latin *pyxis*. The Greek word is similar. The box-tree (Latin, *buxus*) was then, as now, a favorite material for boxes of superior quality, as is evidenced by the common derivation of the name of the thing, and of the material of which it is made. The pyxis of the Greeks and Latins was a jewel-box, and when the great fusion of the two systems took place under Constantine the pyxis became a reliquary.

While the word *box* has with us a generic signification, the older form of the word *pyxis*, shortened to *pyx*, has certain specific meanings: —

1. The box in which the sacramental host is kept in the order of the Roman Church.

2. The box in which sample coins are placed in the English mint. A triannual test by assay for purity is held, and is termed the *trial of the pyx*. Two pieces are taken from each bag of newly coined money, — one for trial in the mint, the other deposited in the *pyx*. The Lord Chancellor summons a jury of goldsmiths, who test by weight and assay in comparison with certain standard *trial-plates* deposited in the Exchequer.

3. The binnacle-box in which a compass is suspended.

4. The *acetabulum* which receives the trochanter at the head of the femur.

Q.

Quad'rant. 1. An instrument for making angular measurements. So called from its embracing an arc of 90° or somewhat more. Formerly much employed in making astronomical observations. When fixed to a wall it was called a *mural quadrant;* this is now superseded by the *mural circle.* See MURAL CIRCLE; MURAL QUADRANT.

The quadrant appears to have been used for solar observations about 290 B. C.; and we learn that the Arabian astronomers, about 995 A. D., had a quadrant of 21 feet 8 inches and a sextant of 57 feet 9 inches radius.

Hipparchus and Ptolemy used *diopters,* in which the distance of a star from the zenith was observed by looking through two sights fixed in a rule, annexed to a second rule, which was kept vertical by a plumb-line, the angular distance between the two rules being measured.

Among the Alexandrian astronomers it was noticed that it was not necessary to use a whole circle (see ARMIL), and Ptolemy says that he found it more convenient to observe altitudes by means of a square flat piece of stone or wood, with a *quadrant* of a circle inscribed on one of its flat faces, about a center near one of the angles. The extreme radii of the quadrant represented the horizon and the zenith lines, and, a peg being placed at the center, the observation was made by reference to the point of the arc upon which the shadow of the peg fell.

The quadrantal form was adopted, as it secured the maximum length of radius in an instrument which could measure the greatest altitude of any celestial body.

The Chaldeans asserted that a man walking without stopping might go round the circuit of the earth in a year. The Alexandrians recognized the rotundity of the earth, and Eratosthenes attempted to determine its size by observing the difference between the altitude of the sun at Alexandria and at Syene on a given day. Syene was found to be on the tropic, for a vertical gnomon at noon on the summer solstice cast no shadow. Alexandria was observed to be distant from the zenith by a fiftieth part of the circumference, and the measured distance between these two cities, which were in the same longitude, was found to be 5,000 stadia. This gave a circumference of 250,000 stadia to the earth, and a radius of about 40,000. This differed considerably from the *opinion* of Aristotle, and slightly from that of Posidonius, the friend of Cicero. The length of the *stadium* used was 202½ yards. See ARMIL; ASTRONOMICAL INSTRUMENTS.

Under the Khalif al Maimun, a measurement of two degrees of the meridian was made in the plain of Sind-jar, in Mesopotamia (elsewhere stated to have been on the shore of the Red Sea). The Arabian astronomers divided themselves into two bands, one proceeding north and the other south, applying their measuring-rods to the ground till each reached a point distant one degree from the starting-point. The respective measurements were 56 miles and 56¾ miles, of 4,000 cubits each. The cubit is stated to have been the "black cubit" = 27 inches, each inch "the thickness of six grains of barley."

The *dhoneys* of the Coromandel coast are navigated by the natives with the assistance of a little instrument for ascertaining the latitude. It consists of a little square board, with a string fast to the center, at the other end of which are certain knots. The upper edge of the board is held by one hand, so as to touch the north star, and the lower edge the horizon. Then the string is brought with the other hand to touch the tip of the nose, and the knot which comes in contact with the nose tells the latitude.

A quadrant was constructed by Copernicus at Thorn in 1510.

In 1590, Davis dispensed with the plumb and adapted the quadrant for use at sea.

Previous to this the astrolabe and mariner's cross had been universally employed by seamen for determining the latitude; the longitude was derived from dead reckoning or guess-work.

The telescope was adapted to the astronomical telescope by Picard.

All these old forms were superseded for nautical purposes by the reflecting quadrant, invented by Sir Isaac Newton, 1670. He communicated the invention to Dr. Halley, who failed to give it publicity, and it was reinvented by Godfrey of Philadelphia, and also by Hadley in England. An instrument construeted on Hadley's plan was submitted to the Royal Society in 1742, and from having been first made known by Hadley, the reflecting quadrant has been generally called Hadley's.

This and all similar reflecting instruments are based on the fact that the angle between the first and last directions of a ray which has undergone two reflections in the same plane is equal to twice the inclination of the reflecting surfaces to each other. Such instruments, therefore, measure angles double the extent of their arc, the degrees and subdivisions being halved; thus, the quadrant, having an arc of 45° only, measures angles up to 90°, the reflecting circle measures two circumferences, and the sextant, which has now largely superseded the quadrant at sea, having a limb of 60° arc, will measure angles of 120°. See SEXTANT.

All measure either vertical or horizontal angles; the quadrant is, however, seldom employed except for taking altitudes of the sun for latitude or local time. The image of an object reflected from a mirror fixed on a pivoted arm is reflected to the other mirror on a fixed arm, where it is again reflected, and by moving the pivoted arm the image is brought into apparent coincidence with the sea horizon, which is viewed through a part of the fixed mirror left unsilvered for that purpose. The movable limb is provided with a vernier, which indicates the degrees and minutes of elevation on the graduated fixed limb.

Fig. 4061.

Gunner's Quadrant.

Graham, Bird, Ramsden, and Troughton are the great names in the history of this instrument, their celebrity being especially due to their great successive improvements in GRADUATING INSTRUMENTS (which see).

2. An instrument used by gunners for giving a cannon or mortar the angle of elevation necessary to attain the desired range. It has a graduated arc and a plumb-line, which indicates the angle of elevation upon the arc when one arm is placed within the bore or the other against the face of the piece in a perpendicular position.

In a more finished and accurate form, a spirit-level is substituted for the plumb, and one of the branches of the instrument is pivoted and slides over the face of the arc so as to show the elevation.

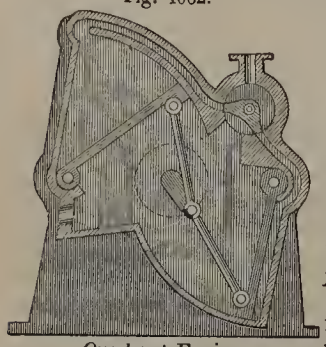
Quad'rant-com'pass. A carpenter's compass, with an arc and a binding-screw.

Quad'rant-e'lec-trom'e-ter. An instrument for estimating the force of an electric current by means of an oscillating needle which traverses against a graduated arc of 90°.

Quad'rant Steam-en'gine. This is a modification of the oscillating-piston engine.

Root's double-quadrant engine has a pair of oscillating single-acting pistons connected by links to one crank. The steam is admitted to act on the outer sides of the pistons alternately by means of one in-

Fig. 4062.



Quadrant-Engine.

duction-valve, and is exhausted through the space between the pistons. The piston and crank connection is such that the steam acts on each piston during about two thirds of the revolution of the crank, and thus there are no *dead-points.*

Quad'rat. 1. A mathematical instrument, formerly known also as a *geometrical square* and line of shadows. It is a rectangular frame two of whose sides are graduated; another side carries two sights. At the corner opposite to the graduated sides is the center of an oscillating index-finger, and from the same point hangs a plummet.

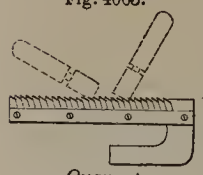
2. (*Printing.*) A block of type-metal lower than the type, and used for filling out lines, spacing between lines, etc. Commonly called a *quad.*

Quad'rels. A kind of artificial stone made of chalky earth dried in the sun. So called from their square shape.

Quad'ru-plex Tel'e-graph. An amplification of the duplex system by which four messages may be sent over a single wire, two in each direction, at the same time. See DUPLEX TELEGRAPH.

Quan'net. The flat file of the comb-maker, having the handle at one side, so as to use like a plane. The teeth incline 15° forward, and are made by a triangular file, not by a chisel. In the illustration, the teeth are made by pieces of saw-teeth inserted into inclined kerfs in a beech stock.

Fig. 4063.



Quannet.

Quant. A bargeman's pole with a flat cap to prevent its penetration of the mud.

Quar'rel. 1. A glazier's diamond.

2. A pane of glass of a diamond or rhombal shape. The term is derived from *quadrum,* something square. The *quarry* or bolt of the cross-bow had a square head and pyramidal point. A *quarry.*

3. A graver, four-sided. A stone-mason's chisel of similar form.

Quar'ry. A diamond-shaped pane of a lead-light window. The *quarries* are fixed in *cames,* which are tied by leaden strips to *saddle-bars* running transversely across the iron frame of the casement window.

Quar'ry-ing. The stones for building the obelisks and colossi of Egypt were taken from the limestone hills which border and inclose the valley of the Nile. The Egyptians then chose the sandstone of Silsilis, where they excavated enormous quantities. Afterward, the granite of Syene was chosen, and of this were the obelisks of Thebes and Heliopolis. The modes of quarrying may have differed somewhat, according to the material and the position. One granite obelisk was broken after it was cut and before it was removed. From the size of the opening it would be impossible to turn the stone, which would require to be lifted bodily, like other stones removed from the same quarry. Bronze was the usual metal of the tools.

The largest stones in any known building are those of the temple platform at Baalbek.

The Egyptian mode of quarrying was by uncovering the stratum of stone, leveling the surface, and marking out an area sufficient to yield the amount of stone required. Around this was cut a deep trench, and cross-trenches at right angles divided the whole area into squares of such a size as was required. Layer after layer was then removed.

Another mode was by working on a perpendicular face, forming a series of steps on the side of the mountain, from which the blocks were lowered by machinery analogous to that which afterward hoisted them into position on the pyramids.

The masses of granite may have been detached from their beds in the same manner as is now practiced in the East. After the stone is surrounded by a trench, it is heated by fire built upon it. The ashes being swept off, water is poured into the groove by a large number of men simultaneously, when the fracture takes place through the whole line.

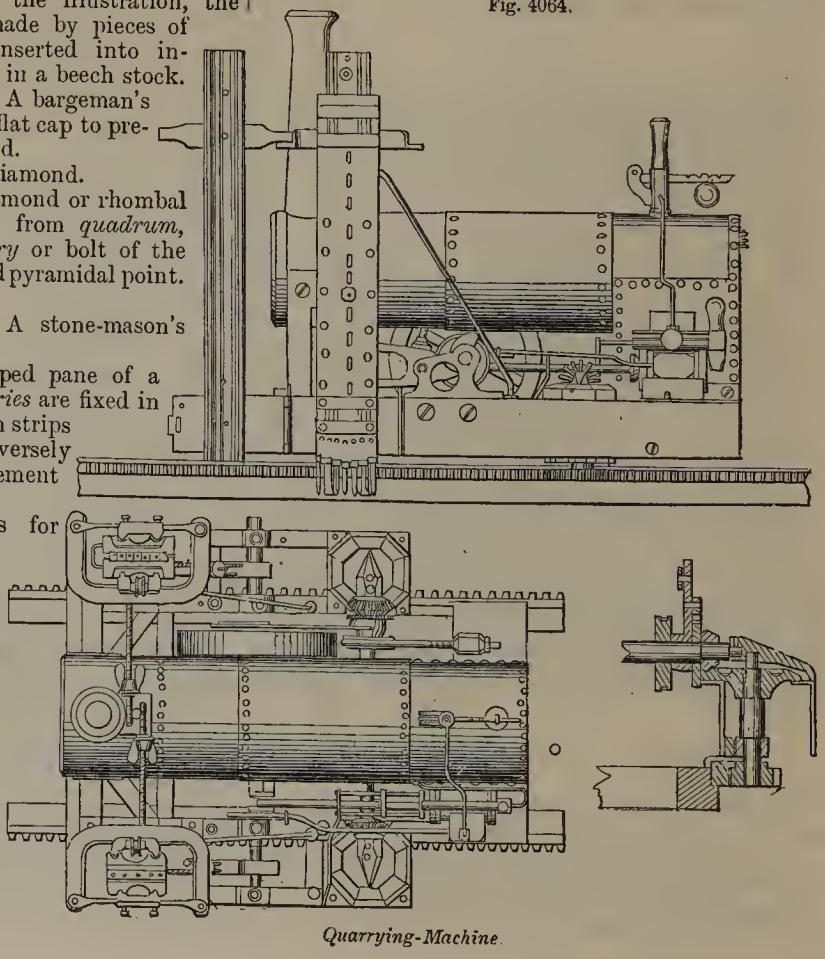
Another mode was to bore perpendicular holes, 18 inches apart, on the desired line of fracture; into these holes small chisels were driven persistently from one end to the other by a number of men, which resulted in a fracture along the line.

Metallic wedges inserted at a number of places and simultaneously driven, was another mode.

Wooden pins inserted into a row of holes and swelled by water, was yet another method.

Quar'ry-ing-ma-chine'. The machine (Fig. 4064) is designed for cutting vertical or inclined channels in the stone preparatory to cutting under and separating the blocks. The boiler, engine, and cutting mechanism are all mounted on the same carriage, which is moved by toothed wheels gearing with a rack upon the rails. By means of a reversible pawl, the carriage may be caused to travel in either direction without reversing the engine. A friction

Fig. 4064.

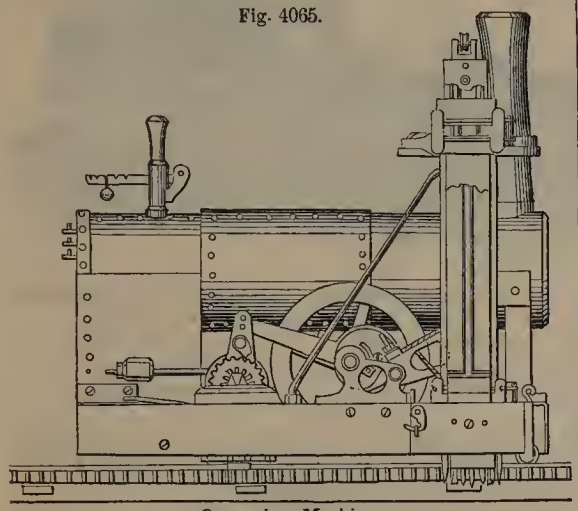


Quarrying-Machine.

brake with an adjustable weight limits the motion of the carriage to the positive distance fed. The chisels are attached to solid stocks moved by vibratory segment-levers. The standard guides between which the chisel-stocks work may be reversed to secure equality of wear and admit of angular adjustment to suit varying inclinations. A balance-wheel serves to equalize the motion of the various parts.

Fig. 4065 is designed for cutting vertical or inclined channels in beds of stone preparatory to undercutting and removing the blocks. The engine and

Fig. 4065.



Quarrying-Machine.

cutting mechanism are carried on a single truck, which is advanced by spur-wheels gearing with a rack on the rails. The chisels are reciprocated by segment-levers; a brake limits the motion of the machine, and a reversible pawl permits its direction to be changed without reversing the engine.

Quar'ry-stone Bond. Rubble masonry.

Quar-ta'tion. (*Metallurgy.*) The process formerly employed of separating gold from silver by means of nitric acid. This would not act effectually upon an alloy containing less than $\frac{3}{4}$ silver, so that when the mixture was richer in gold, silver was added to make this proportion.

Quar'ter. 1. (*Nautical.*) *a.* The side of a ship, aft, between the main channels and stern. *On the quarter*, 45° abaft the beam. *Quarter*-boats are abaft the mizzen. *Quarter*-deck, abaft the mainmast.

b. Portions of a ship belonging to or at the quarter, as, *quarter-boat, quarter-gallery, quarter-ladder, quarter-nettings, quarter-posts, quarter-rails, quarter-timbers*, etc.

c. That portion of a yard from the slings outward; hence, *quarter-block, quarter-slings, quarter-tackle*, etc.

d. A point of the compass between the line of the keel and abaft the beam.

e. The stations of a ship's company in time of exercise or action.

2. (Plural, *quarters.*) The apartments assigned to officers and soldiers in a barrack.

3. (*Milling.*) A section of a millstone dress, consisting of a *leader* and its branches; the term is used irrespective of the number of degrees embraced in the sector. See MILLSTONE.

4. (*Coopering.*) The portion of the side of a cask intermediate between the *chime* and the *bulge.*

5. (*Cork-cutting.*) A parallelopiped of cork, blocked out and ready for rounding into a cork shape.

6. (*Carpentry.*) *a.* An upright stud or scantling in a partition which is to be lathed and plastered. The English rule is to place the quarters at a distance not exceeding 14 inches.

b. A section of a winding stairs.

7. The rear or heel portion of a horseshoe.

8. (*Architecture.*) A portion of a Gothic arch.

9. (*Shoemaking.*) The portion of a boot or shoe upper behind the ankle-seams.

Quar'ter-blan'ket. (*Menage.*) A small blanket generally used under the harness, covering the horse's back from the shoulders to the hips, though in some cases it extends no farther forward than the front of the pad.

Quar'ter-block. (*Nautical.*) A double block iron bound, secured swivel fashion by a bolt near the middle of a yard. Through it passes the *clew-garnet* or *clew-line*, as the case may be.

Quar'ter-boot. (*Menage.*) A leathern boot designed to protect the heels of the horse's fore-feet from injury by overreaching with the hind feet.

Quar'ter-deck. (*Nautical.*) A deck raised above the waist and extending from the stern to the mainmast. It is especially a privileged portion of the deck, being the promenade of the superior officers of the vessel or of the cabin passengers in vessels of that character. The windward side is the place of honor.

Quar'ter-gal'ler-y. (*Shipbuilding.*) A small balcony on the quarter of a vessel.

Quar'ter-hol'low Tool. (*Wood-turning.*) A chisel (*c*, Fig. 4066) for making convex moldings.

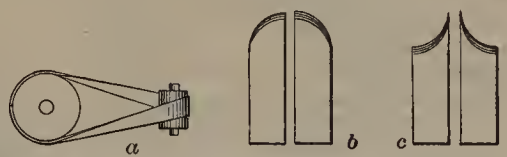
Quar'ter-hung. (*Ordnance.*) Said of a gun whose trunnions have their axis below the line of bore.

Quar'ter-ing. 1. (*Machinery.*) The adjustment of cranks on a single shaft at 90° distance apart, or the boring of wrist-pins in locomotive driving-wheels at right angles with each other.

2. (*Nautical.*) Sailing large but not before the wind.

Quar'ter-ing-belt. (*Machinery.*) A belt or

Fig. 4066.



a, Quartering-Belt. b, Quarter-Round Tool. c, Quarter-Hollow Tool.

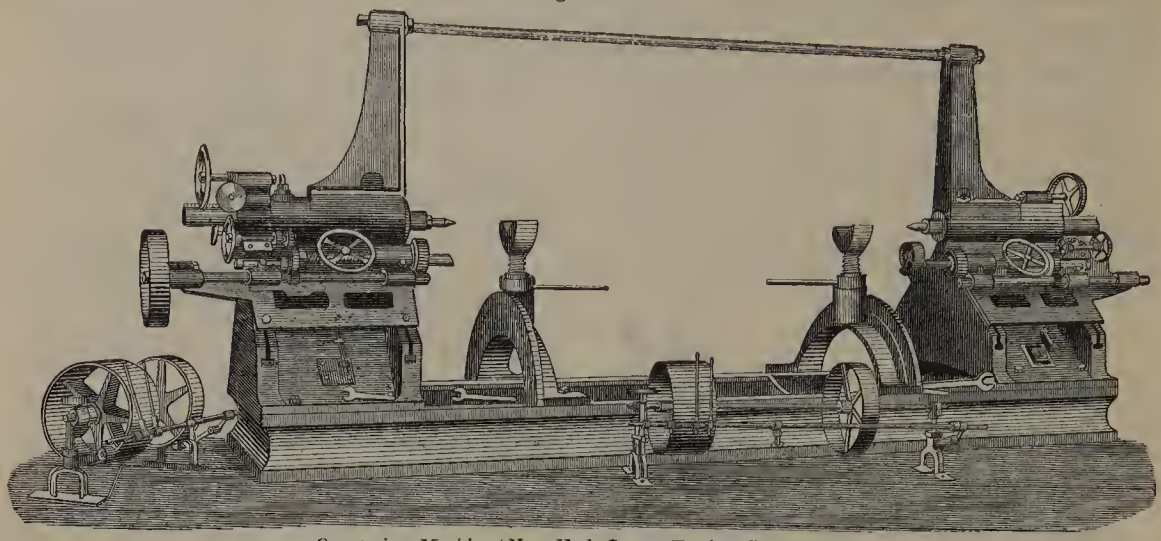
band (*a*) connecting pulleys whose axles are at right angles to each other.

Quar'ter-ing-ma-chine'. A machine for quartering car driving-wheels on their axles, that is, boring the wrist-pin holes at 90° distance apart. A pair of wheels mounted on their axle is placed in the machine, the axle resting upon a pair of vertically adjustable rests, which take the weight off the centers. The boring-heads are adjustable radially from the center of revolution, so as to bore the holes for the wrist-pins at a distance equal to one half the stroke of the piston; a range of adjustability of, say, from 12 to 26 inches stroke. The machine is built for right or for left hand quartering, but, by being fitted with four boring-bars, is adapted for both kinds of quartering. See Fig. 4067.

Quar'ter-pace. (*Building.*) A stair embracing a quarter-turn at the winding of a stairs.

Quar'ter-pie'ces. (*Shipbuilding.*) Timbers in the after part of the quarter-gallery near the *taff-rail.*

Fig. 4067.



Quartering-Machine (New York Steam-Engine Company).

Quar'ter-round. A plane used for molding framework. An *ovolo.*

Quar'ter-round Tool. (*Wood-turning.*) A chisel (*b*, Fig. 4066) for making concave moldings. They are *right* and *left.*

Quar'ters. 1. (*Carpentry.*) Vertical scantling in wooden partitions, forming a foundation for lath and plastering.

2. *a.* The apartments assigned to officers and soldiers in a barrack.

b. The stations of a ship company on duty.

Quar'ter-stuff. (*Carpentry.*) Plank one quarter inch thick.

Quar'ter-tim'ber. (*Carpentry.*) Scantling from 2 to 6 inches deep.

Quar'to. (*Printing.*) A book formed by folding a sheet twice, making 4 leaves, 8 pages. The term, by modern usage, refers to a book of a nearly square form. The proportions vary according to the sizes of the sheets folded, but may be from $8\frac{1}{2} \times 10$ to 10×12, and probably both below and above said dimensions.

Quartz-crush'er. A machine for breaking or grinding auriferous quartz. Also used for breaking other ores; or stones for cement, to mix with asphalt for paving, etc. See QUARTZ-MILL.

Quartz-liq'ue-fi-er. An apparatus for dissolving comminuted quartz in order to set free the gold. By converting the quartz into a silicate of an alkali, it may be washed away, the gold being collected by precipitation and decantation of the supernatant solution. It is a process which depends in part on the facilities for using the soluble glass, and requires great volume of water.

See the patent of Hardinge, May 8, 1855. The powdered mineral is exposed to high-pressure steam and alkali in a closed chamber of a spheroidal form, a rotary stirrer mixing the ingredients. See also Vanderburgh's patent, May 29, 1860; and Fleury, July 7, 1868.

Quartz-mill. (*Ore.*) A machine for crushing quartz, to bring it down to a size suitable for the stamps, or to a fineness for the amalgamator. See also ORE-MILL.

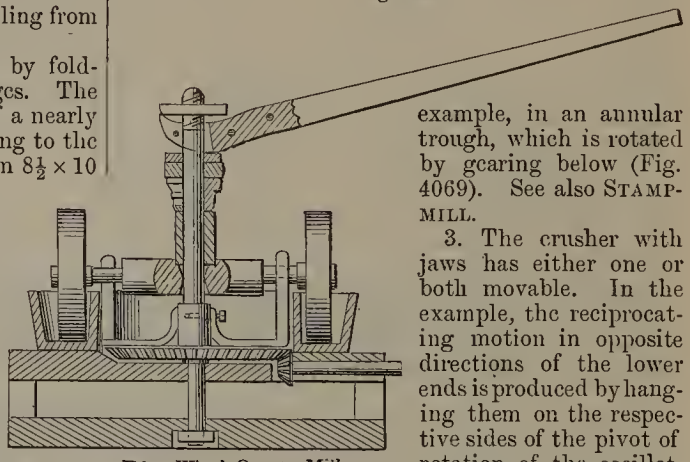
The following are typical forms, of each of which there are many varieties: —

1. The *Chilian-mill*, consisting of edge-stones traveling in a trough.
2. The stamp-battery.
3. Vibrating jaws.
4. Rotary beaters.
5. Horizontal runner.
6. Vertical runner.
7. Bell-shaped runner
8. Conical mill.
9. Inclined disks.
10. Rolling-ball.
11. Gyrating-pan.

1. Fig. 4068 is an edge-mill, the stones traveling in an annular trough, the weight increased by a lever. See also CHILIAN-MILL.

2. The stamping-mill has a battery of stamps, either each acting in its own mortar, or, as in the example, in an annular trough, which is rotated by gearing below (Fig. 4069). See also STAMP-MILL.

Fig. 4068.



Edge-Wheel Quartz-Mill.

3. The crusher with jaws has either one or both movable. In the example, the reciprocating motion in opposite directions of the lower ends is produced by hanging them on the respective sides of the pivot of rotation of the oscillating levers, and their upper ends are caused to approach by the rear supporting links, which are vibrated by the reciprocation of the jaws. Fig. 4070. See also ORE-MILL.

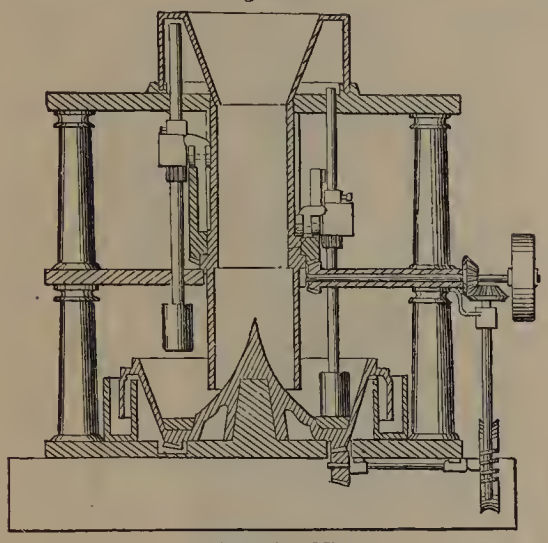
4. The rotary beater. The ore passes from the hopper into the first cylinder, the beaters on the shaft forming a partial vacuum. The beaters strike the ore, which is carried by the peripheral force of the current through the connecting passage into the second chamber, through which it receives the same treatment, and passes to the connecting-pipe, which deposits it in the dust-chamber. Fig. 4071.

5. Horizontal runner. The stone is suspended above the bed, and is fed through the eye, as with grist-mills. Fig. 4072.

6. The runner on horizontal shaft. The cylinder surrounds the grinding-wheel, which is eccentrically journaled in respect to it, and revolves at different

speed thereto. The matter to be crushed enters one end of the cylinder, and passes out beneath the shields and gauze-covered openings near the periphery of the same. The cylinder runs on anti-friction rollers. Fig. 4073.

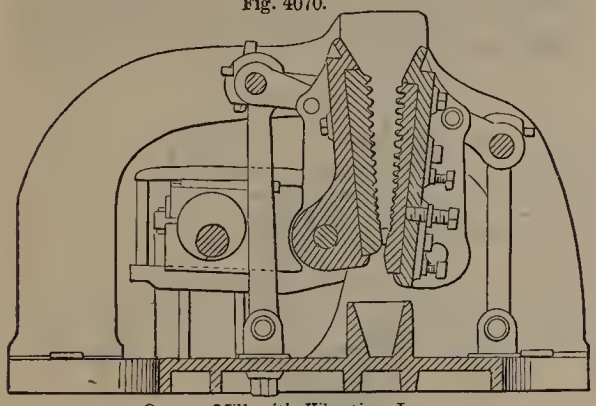
Fig. 4069.



Stamping-Mill.

7. Bell-shaped runner in conical case. This has two revolving toothed surfaces, one within the other, the interior in the shape of a cone, and the other one formed around the interior; both of these parts revolve in the same direction, but the interior one much faster than the outer. Fig. 4074.

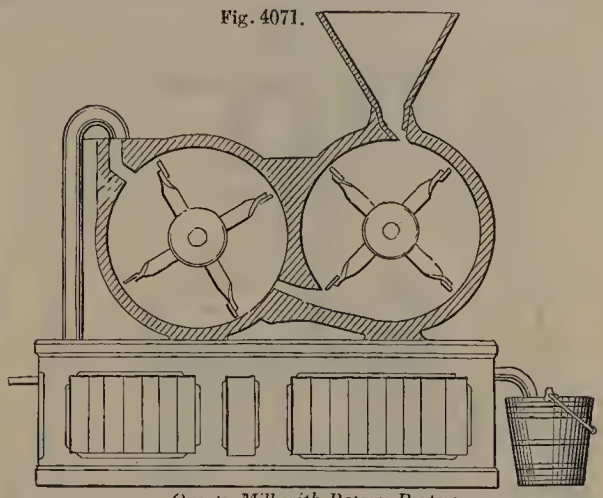
Fig. 4070.



Quartz-Mill with Vibrating Jaw.

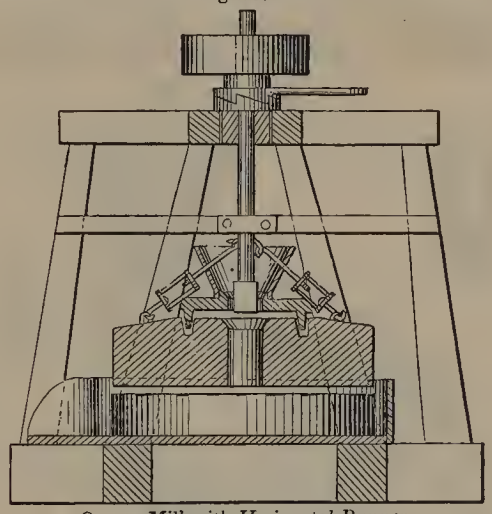
8. Conical mill. The ore is broken and thrown into the hopper, and passes between the vertical compound wheel of the hopper and the concave, which is formed of segmental blocks. From thence it passes to the final reducing stones. Fig. 4075.

Fig. 4071.



Quartz-Mill with Rotary Beaters.

Fig. 4072.

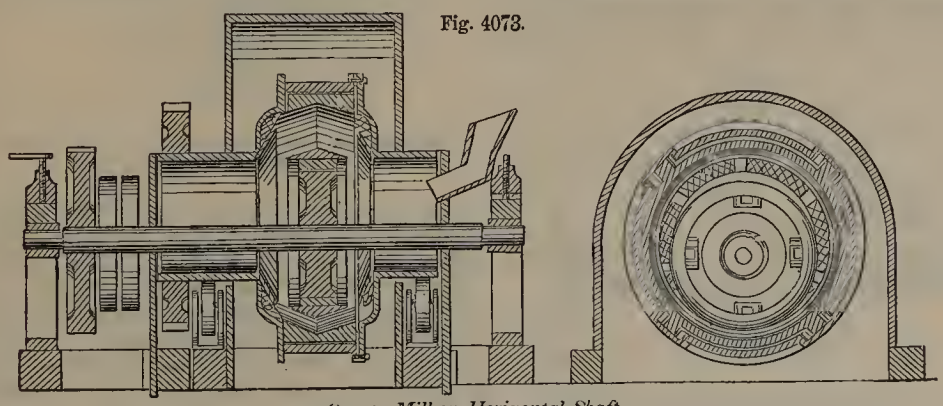


Quartz-Mill with Horizontal Runner.

9. Inclined disks. This has two revolving disks with conical-shaped surfaces revolving in different directions, and hung upon shafts placed diagonally to each other, so as to bring the two faces of two grinding disks parallel with each other. Fig. 4076.

10. The rolling ball. This has a stationary mor-

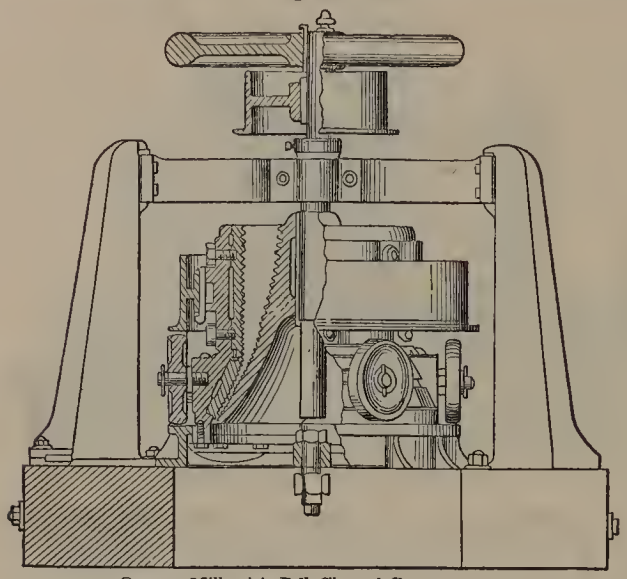
Fig. 4073.



Quartz-Mill on Horizontal Shaft.

tar or kettle, of a partly spherical form in the interior, with a spherical concentrical ball operated by

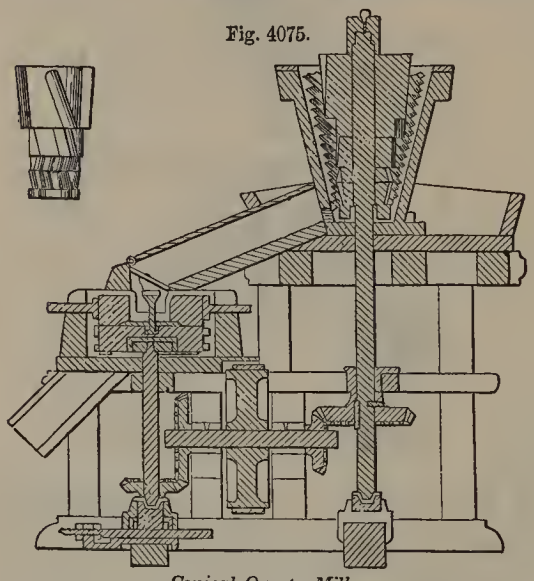
Fig. 4074.



Quartz-Mill with Bell-Shaped Runner.

a diagonal shaft connected, by means of an arm and forked joint and bush, with a vertical driving-shaft.

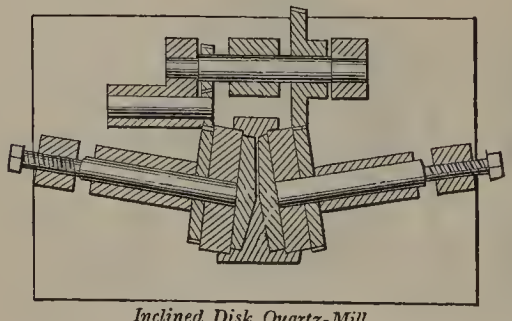
Fig. 4075.



Conical Quartz-Mill.

The ball, mortar, or basin is combined with the vertical hollow shaft, so that ores that are pulverized are carried down continuously, without intervals for

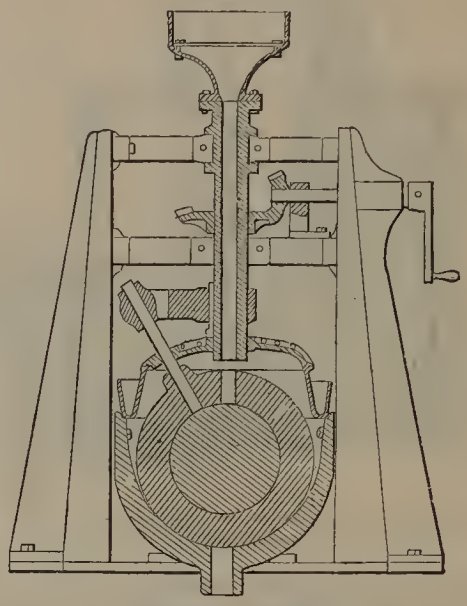
Fig. 4076.



Inclined Disk Quartz-Mill.

charging or discharging, the falling ores being equally distributed on all sides of the ball and basin. Fig. 4077.

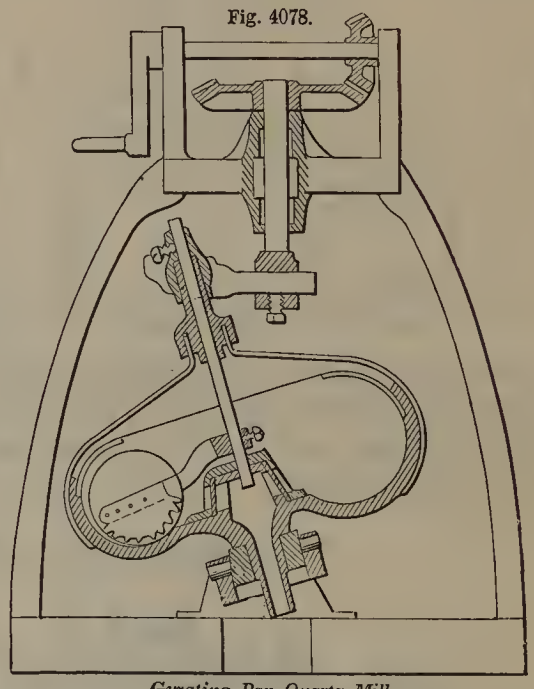
Fig. 4077.



Rolling-Ball Quartz-Mill.

11. Gyrating pan. This has an oscillating basin, the lower end of whose shaft is connected with and rotates in the hub of the machine. Upon the axle or shaft is adjusted the ring or bush, which is fitted with slots to receive and hold firmly the iron bands

Fig. 4078.



Gyrating-Pan Quartz-Mill.

or straps; the object of which is to support and strengthen the basin. Within the basin is placed the ball which is to pulverize the ore. Fig. 4078.

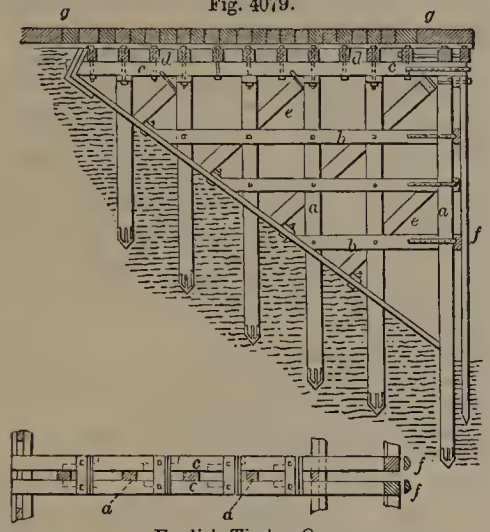
Quay. A wharf projecting into a stream, harbor, or basin, to which vessels are moored for the purpose of receiving and delivering freight.

In Europe, quays are generally formed by retaining walls of stone, supported by counterforts and backing; in this country, wood is generally em-

ployed. The quays of Montreal are the best on the continent. See SEA-WALL, where the mode of construction of the New York harbor-quays is represented. See also FLOATING-DERRICK.

Fig. 4079 is a section and plan of a timber quay as constructed in England.

Fig. 4079.



English Timber Quay.

a a, side piles.
b b, side wales.
c c, cross beams.
d d, top beams.
e e, side braces.
f f, fender piles.
g g, planking.

The details and nomenclature are somewhat different in this country. See WHARF.

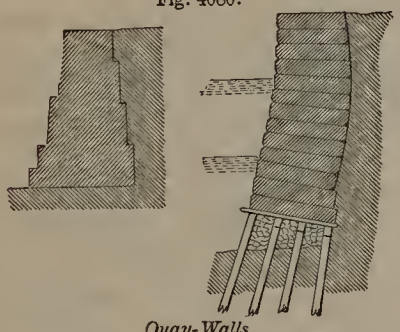
Cast-iron piling has been successfully employed at Deptford and Blackwall, England.

A *quay* occupies the same relation to a *harbor* that a *wharf* does to a *river*.

Harbors and docks are provided with *quays*, and their construction involves some of the precautions incident to the building of jetties, sea-walls, retaining walls, etc. The quay, however, is not subjected to the violent action of the waves incident to the construction first mentioned and to *breakwaters*. The thrust of the soil is, perhaps, the greatest force tending to its destruction.

The quay-wall of the outer harbor of Havre has a

Fig. 4080.



Quay-Walls.

Havre. *Rennie's.*

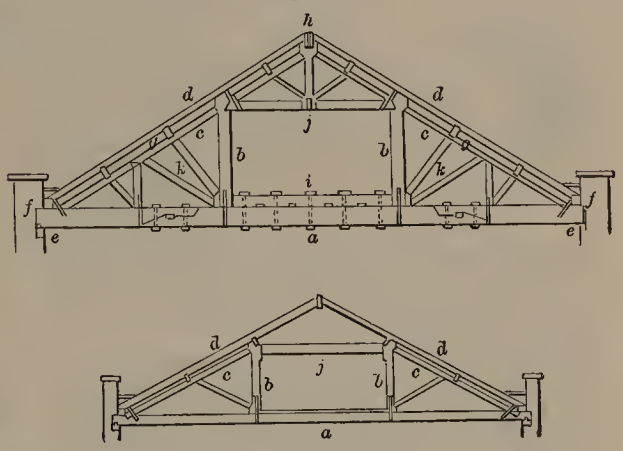
mean thickness equal to 0.40 of its hight, and batters on both sides by a series of steps.

Rennie advised a curvilinear batter on both sides, laying the courses normally to the curve. This entails the necessity of using inclined piles, which introduces an element of insecurity. The face of the quay-wall forms the intrados of an arch and makes the ashlars mutually sustaining. Whether the latter advantage overbalance the detrimental effect of inclined piling is doubtful.

The Dutch are said to run the sides of the walls parallel, that is, make them of equal thickness, so that the batter of the outside causes an overhang of the inside. This seems indefensible.

Queen-post. Queen-posts are mortised or attached by iron straps to the tie-beam of a roof-frame, supporting it and the rafters at points between the *ridge* and *eave*. *Purlins* rest upon the principal rafters, and common *rafters* rest upon the *purlins*. The former are let into the tie-beam, and the latter butt against the pole-plates.

Fig. 4081.



Queen-Post Roof.

a, tie-beam.
b, queen-posts.
c, principal rafters
d, common rafters.
e, wall-plates.
f, pole-plates.
g, purlins.
h, ridge-plate.
i, straining-sill.
j, straining-beam.
k, struts.

Queen's-met'al. An alloy intermediate between Britannia metal and pewter. Used for spoons, teapots, and other table-ware.

Tin	9	Antimony	1
Lead	1	Bismuth	1

Or, —

Tin	100	Bismuth	1
Antimony	8	Copper	4

Quench'ing. The process of producing a hard scale or crust upon the surface of molten metal in a crucible or cistern, for the purpose of removing it in successive rondles or disks, instead of allowing it to congeal into a solid mass.

. *Rose-copper* is thus removed from the crucible of the refining-hearth, the disks being known as *rosettes*.

Quench'ing-tub. (*Blacksmithing.*) The vessel in which the heated iron or steel from the forge is plunged, in order to cool or temper it.

Quern. A hand-mill of the ancient pattern. See GRINDING-MILL.

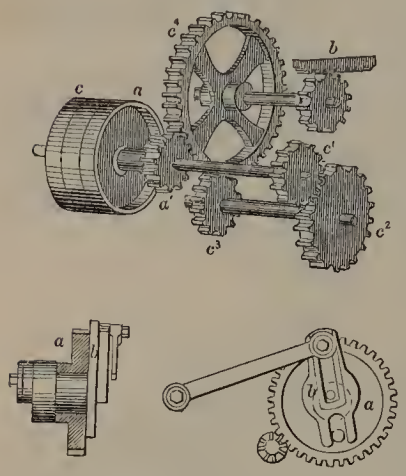
A Roman *quern* dug up in Yorkshire, England, about 1710, was found to be 20 inches in diameter. One stone was somewhat dished, and the other slightly conical. The face had a *dress* of notches.

Quick-match. Cotton-wick is boiled in saltpeter and rain-water for 1 hour; alcohol is added to the mixture while warm, and it is simmered for 15 minutes. Mealed powder is then added, and the whole left for 24 hours. The cotton-wick is wound on a reel, and mealed powder sifted over it. It is then dried.

Quick-re-turn' Gear'ing. (*Planing-machine.*) Gear for causing the rapid return of the bed after the tool has completed each cut.

This is effected (see upper figure) by the pulley *a*

Fig. 4082.



Quick-Return Gearing.

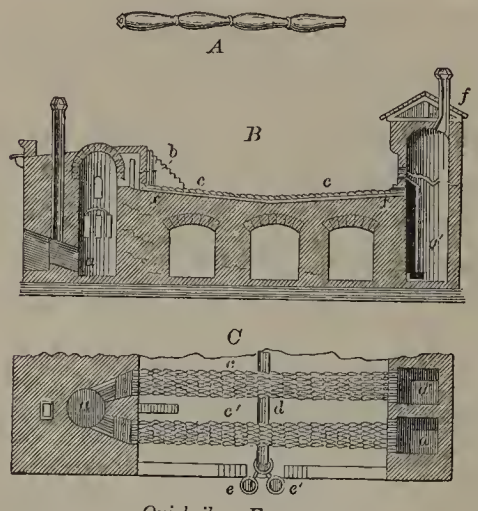
and pinion a'. The bed is moved from left to right, presenting the work to the cutting edge of the tool by the rack b, operated from the pulley c through the gears $c^1\,c^2\,c^3\,c^4$. On arriving at the end of its motion, a stud on the lathe-bed strikes a horn, which shifts the driving-belt from c to a, causing the pinion a' to reverse the movement of the gear c^4, and turn the bed in the opposite direction, until the belt is shifted back to its original pulley by a similar device at the other end of the machine.

Whitworth's quick return for shaping-machine (lower figures). A spur-wheel a, revolving freely upon a large fixed overhanging shaft, is attached to a convenient part of the head. Through, but not concentric with, the shaft, runs a spindle, having a slotted crank-piece b on its extremity, by which it is kept in contact with the face of the wheel, and connected therewith by a pin engaging in the slot; the velocity of the crank varies as the pin approaches or recedes from the center, supposing that of the wheel to be uniform. The end of the connecting-rod may be set at any point in the dovetail groove in the face of the crank-piece, for adjusting the length of stroke.

Quick'sil-ver. See MERCURY.

Quick'sil-ver-fur'nace. (*Metallurgy.*) Fig. 4083 illustrates the furnace employed at Almaden, Spain, for obtaining metallic mercury from cinnabar. *A* shows part of a chain of aludels, *B* is a vertical

Fig. 4083.



Quicksilver-Furnace.

longitudinal section, and *C* a horizontal section of the furnace, the part $x\,x$ being in plane. This consists of two upright cylindrical shafts $a\,a'$, separated by an arched space $x\,x$. The fire is made in the shaft a, and immediately over it is placed a quantity of sandstone containing a small proportion of cinnabar; over this is laid the richer ore, and the openings in the shaft are covered with tiles and tightly luted.

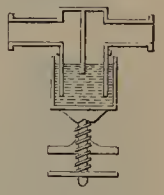
The mercurial vapors evolved are conducted into the space b, and thence pass through the rows of aludels $c\,c'$, 12 in number and 20 to 22 meters in length.

The metallic vapors condensed in the aludels run into the gutter d, and are collected in stone cisterns $e\,e'$, while those which are not condensed pass into the chamber a', where the mercurial portion passes into the liquid state, the smoke escaping from the chimney f. As the mercury thus obtained is contaminated with soot, it is caused to flow down an inclined plane, to which the smoky impurities adhere. The matters condensed in the chamber a' are redistilled to extract the metal. The quantity of ore employed at each operation is 250 to 300 cwt. See also MERCURY.

Quick'sil-ver-valve. A valve in which the lower edge of a descending plate becomes submerged in quicksilver to close a passageway.

It resembles the hydraulic valve, except in the substitution of metal for water or glycerine. The two pipes meet in a box having a descending plate and a circular flange, the lower edge of which latter is constantly submerged in a box of quicksilver.

Fig. 4084.



Quicksilver-Valve.

The box has a capacity for vertical adjustment by a screw beneath, so that the middle plate may dip into the quicksilver and close the communication between the pipes; or the box may be lowered so as to allow the communication to proceed.

Quick-wa'ter. (*Gilding.*) A dilute solution of nitrate of mercury (10) and gold (1), used in the process of *water-gilding* (which see).

Quick-work. (*Shipbuilding.*) Inside planking or skin, between ports.

Quill. 1. (*Seal-engraving.*) The hollow mandrel of the lathe or engine used by the seal-engraver. See SEAL-ENGRAVING.

2. A small spindle, pirn, or rod upon which thread is wound to supply the shuttle with the *woof*, *weft*, or *filling*, as it is variously called, and which crosses the *warp*, or *chain*.

Quill-bit. A long pod-bit of small diameter.

A wood-boring tool used in a brace. It is of a semi-cylindrical form, terminates in a sharp edge, and is hollow, to contain the chips. See BIT.

Quill-nib. A small pen of quill to be placed in a holder.

Quill Pen. The quills of birds came into use as pens about the 6th century A. D., according to Isidore and others. (See PEN.) We read of the use of quills of the swan, eagle, goose, duck, and crow. After the discovery of America the quills of the turkey were so used. This very American bird was absurdly named after the country of the Turks. The turkey-quill was perhaps the first whose nibs were furnished with metallic points. This was early in the present century.

Goose-quills are assorted into qualities determined by the character of the barrel. They are plunged into heated sand, to make the exterior skin peel off and the interior membrane shrivel up. This may be performed by alternate soaking in water and drying before a charcoal fire. They are hardened by soaking in a hot solution of alum.

The yellow color is conferred by a quick dip into nitric acid.

Bramah probably first suggested quill-nibs, and patented a machine for making them. These nibs were the precursors of the steel nibs. Iron pens were mentioned by Chamberlayne in 1685. Not like the iron pen of Job, which was a chisel or graver. See STEEL PEN.

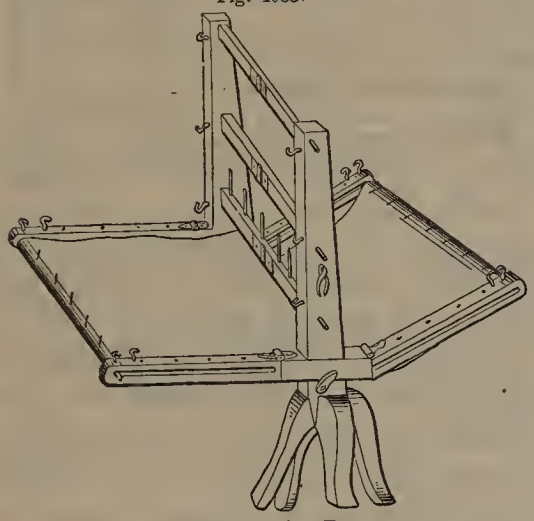
The barrels of the quills were first slit longitudinally into halves; these were subdivided into blauks for nibs, and the latter were formed and slit in a third operation. See PEN-MAKER.

Quilt'ing. 1. Loom-made quilts appear to be two distinct cloths, tied, as it were, together by stitches which go through both cloths, and by the crossing and interchange of warp-threads from the lower to the upper set, and *vice versa*, in the manner of the two-ply carpet. In some quilting a third shuttle throws in a quantity of coarsely spun cotton, to serve as a kind of wadding.

2. (*Nautical.*) Braided or plaited sennit over a bottle, etc.

Quilt'ing-frame. A frame on which fabric is stretched for quilting. The old-fashioned frame

Fig. 4085.



Folding Quilting-Frame.

was as large as the quilt, and the modern conveniences are to secure compactness and facility of exposure of that part on which work is proceeding, the other portions being covered from the dust.

Fig. 4086.

Roller Quilting-Frame.

Fig. 4085 is a frame with jointed leaves, which fold up against the standard.

In Fig. 4086, two rollers are journaled in the front ends of the frame and one in the rear. On the outer front roller is wound the outside portion of the article to be quilted, and on the inner roller is wound the lining. The part quilted is wound on the rear roller.

Quire. *a.* A collection of 24 sheets of paper. Wrapping, envelope, flat-cap, printing, and many other papers are not folded. Newspaper has 25 sheets to the *quire;* 10 quires to a *token;* 2 tokens to a ream. When work is calculated by the 1,000 sheets, 250 sheets are usually known as a *token.*

b. A collection of one of each of the sheets of a book laid in consecutive order ready for folding. The sheets are *gathered* into a *quire* or *book*, which is folded along the middle.

Quirk. 1. A sudden turn; applied to a form of molding in which an acute recess separates the molding proper from the *fillet* or *soffit.*

It is much used between moldings in Gothic architecture; in Grecian architecture ovolos and ogees are usually quirked at the top, and sometimes in Roman.

2. A projecting fillet on the sole or side of a grooving-plane, which acts as a *fence* or a gage for depth or distance.

Quirk-float. (*Plastering.*) The plasterer's tool for finishing off angles. An *angle-float.*

Quirk'ing-plane. A molding-plane for working on convex surfaces.

Quiv'er. An arrow-case.

They were strapped to the sides of the Egyptian chariots, but are usually carried on the back, so that the arrows may be grasped by the hand when reached over the right or the left shoulder. The Apache Indians carry it over the right shoulder, so that the heel of an arrow may be grasped by the least possible reach of the right hand. The arrows are so quickly drawn and thrown into position upon the left hand, which grasps the bow, that the man will keep four or five arrows flying in the air at the same time. Much care and ornament are bestowed upon this article by barbarous nations.

Quoin. 1. A wedge-shaped block. Specifically: —

a. (*Gunnery.*) A wedge-shaped block of wood, having a handle inserted in its thicker extremity; used in some cases for giving the proper elevation to mortars, howitzers, and naval guns.

b. (*Printing.*) One of the wedges by which the pages or columns of type are locked in a *chase*, ready for printing.

c. (*Nautical.*) A wedge used as a chock in stowing casks, to prevent rolling.

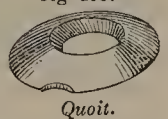
2. (*Masonry.*) An external angle of a wall. The term particularly refers to ashlar or brick corners which project beyond the general faces of the walls which meet at the angle.

Rustic quoins are rusticated ashlars forming external projecting corners, the remainder of the wall being of ordinary masonry, rubble, or brick, with occasional piers of masonry. See RUBBLE-MASONRY.

Quoin-post. (*Hydraulic Engineering.*) The heel-post of a lock-gate. See Fig. 1386, page 594.

Quoit. An annular disk beveled roundly on each side, thrown by hand at a stake or peg in playing the game of quoits.

Fig 4087.



Quoit.

This game is of unknown antiquity, throwing the *discus* having been a favorite sport with the ancient Greeks, and in some form appears to have existed from time immemorial, among even the most uncivilized nations

The ancient quoit was a heavy circular mass of iron, sometimes perforated in the middle; and the effort was not one of skill, to throw it as nearly as possible to the mark, now called the *hob*, but to throw it to the greatest possible distance, as in the modern Scotch games of *putting the stone* or *hurling the hammer.* Homer mentions the throwing of the δύσκος among the sports at the funeral games of Patroclus (Iliad, II., XXIII. See also Odyssey, VIII., XVII.). Sometimes a thong was passed arouud it to form a handle; in the Cabinet des Antiquités of Paris is preserved a *discus* with hole for the thumb and fingers. Pindar celebrates the skill of Castor and Iolaus in this exercise. In the British Museum is the famous statue of the *discobolus* in the act of throwing the *discus.* Quoit-pitching was a favorite pastime in England. Notices of it are found in 1453. The horse-shoe is a common substitute in America.

R.

Rab. A stick used in mixing hair with mortar.

Rab'at. A polishing material formed of potter's clay which has failed in baking.

Ra-bat'ment. (*Shipbuilding.*) The draft of the real shape of the molding edges of pieces of the frame in any required position.

Rab'bet. 1. (*Carpentry.*) A rectangular groove made longitudinally along the edge of one piece to receive the edge of another. A *rebate.*

It is common in paneling, and in door-frames for the door to shut into.

2. (*Shipwrighting.*) That part of the keel, stern, and stern-post of a ship which is cut for the plank of the bottom to fit into.

Rab'bet-ed Lock. (*Locksmithing.*) A kind of lock whose face-plate is sunk within a rabbet cut in the edge of a door.

Rab'bet-ing-ma-chine'. A machine for forming rabbets. Rabbeting-machines for wood, as well as other kinds of planing and molding machines, were supplied by General Sir Samuel Bentham to the British Admiralty before 1800. Many *planing*-machines and all *matching* and *molding* (wood) machines may be set to cut rabbets.

Rab'bet-joint. (*Carpentry.*) A mode of joining wooden stuff in which rabbets are made upon the contacting edges of the boards, so as to overlap each other. See JOINT.

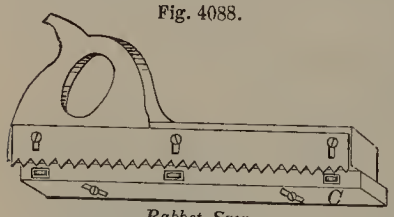
Rab'bet-plane. (*Joinery.*) A plane for plowing a groove on the corner edge of a board. According to their shape, which is such as to adapt them to peculiar kinds of work, they are known as *square-rabbet, side-rabbet, skew-rabbet* planes.

The *square-rabbet* plane has its cutting edge square across the sole.

Skew-rabbet plane; the bit obliquely across the sole. *Side-rabbet* plane; having the cutter on the *side*, not the *sole.*

Rab'bet-saw. A saw adapted for forming grooves in the edges of plank, etc. That illustrated has an adjustable fence or gage *C* attached to a handle similar to a plane-stock, so as to cut at variable distances from the edge.

Fig. 4088.



Rabbet-Saw.

Rab'ble. (*Metallurgy.*) An iron bar with an end bent at a right angle, used for stirring the molten iron in the puddling or boiling furnace, for removing slag from the surface, and for gathering the metal into *loops* or *balls* for the tilt-hammer or squeezer.

A *mechanical rabble* is used in some forms of puddling-furnaces. See page 1815.

Rab'bler. (*Metal.*) A scraper.

Ra'bot. (*Marble-working.*) A hard-wood rubber used in rubbing marble to prepare it for polishing.

Race. 1. (*Hydraulic Engineering.*) The canal or course by which water is conducted to a water-wheel from the mill-pond or stream above, and is conveyed away after having done its work. The water reaches the wheel by the *head*-race and leaves it by the *tail*-race.

2. (*Loom.*) The path or guiding trough for the shuttle in the *lay* or *batten.*

Race-cloth. (*Menage.*) A cloth used in connection with race-saddles; it has pockets to hold the weights needed to meet the requirements of the rules of the race-course.

Race-glass. (*Optics.*) A common name for a lorgnette or binocular field-glass.

Race-knife. A tool with a bent-over, sharp lip for scribing. It is used in laying down on the floor the lines on the body plan, by which the smith bends his bars in forming iron frames for ships.

Fig. 4089.

Race-Knife.

It is also used for marking, numbering, and other purposes.

Race-sad'dle. (*Menage.*) A very small light saddle, used only for racing purposes.

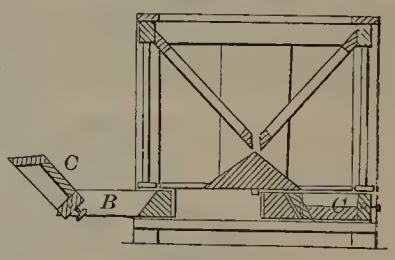
Rach'i-o-tome. (*Surgical.*) A post-mortem or dissecting instrument for opening the spinal canal.

There are two kinds: one, a saw with double blades, which are caused to approach or recede from each other by means of set screws, making two parallel cuts at once; the other, an axe-like chisel with a round, projecting point, which is inserted into the hollow of the vertebræ and guides the chisel while the operator holds it by the handle with one hand, striking on it with a hammer held in the other hand.

Rac'ing-bit. (*Menage.*) A jointed-ring bit, made very light, the loose rings varying in size from 3 to 6 inches.

Rack. 1. (*Husbandry.*) A frame of open-work to hold hay or other feed for cattle, horses, or sheep. The example is a sheep-rack; has a grain-trough *B C* pivoted in a drawer beneath the bars of the hay-rack, so that it may be folded and slid in, rendering the arrangement more compact and preventing the animals having access to the food except at stated times. A *feed-rack.*

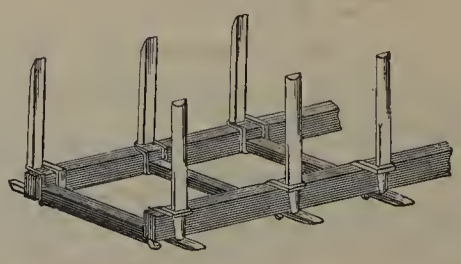
Fig. 4090.



Sheep-Rack.

2. (*Wagon.*) A frame to carry hay or grain, placed on a wagon-gears instead of a box-bed, for hauling in the harvest. Sometimes it is laid upon the wagon-bed; but this is not so good, as the bed makes the load too high and too short, and adds unnecessary dead-weight.

Fig. 4091.



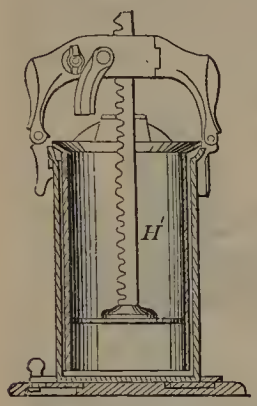
Wood-Rack.

The device is also placed on a wagon-frame for hauling wood and other materials.

Fig. 4091 is a wood-hauling rack in which the sleepers, sills, and stakes are united by the bent stirrups, and are disunited by raising the stakes.

3. (*Gearing.*) A toothed bar whose pitch-line is straight, or, if curved, embraces but a fraction of the

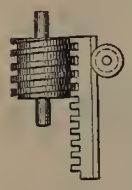
Fig. 4092.



Rack-Movement (Lard-Press).

circle and is called a segment-rack, for imparting rectilinear motion, and operated by a toothed pinion or segment or by a pawl.

Fig. 4093.



Rack and Worm.

In the example, where it works the piston of a lard-press or sausage-stuffer, the rack H′ is raised or lowered by a pinion, and may be held at any desired hight by a pawl engaging a ratchet-wheel on the pinion-shaft.

The rack and worm (Fig. 4093) may in some cases be substituted with advantage for the rack and pinion. The teeth of the rack are oblique, to correspond with the threads of the endless screw or worm.

4. (*Metallurgy.*) An inclined frame or table, open at the foot, and upon which metalliferous slimes are placed and exposed to a stream of water, which washes off the lighter portions. It is to the *slimes* what *buddling* is to the *ores*. The operation is known as *racking*, *recking*, and *framing* in different districts of Cornwall, and particularly applies to tin ores. See FRAME.

5. (*Horology.*) A steel piece in the striking part of a clock. It consists of a bar attached radially to an axis, and having a lower and an upper arm. The former is called the *rack-tail*, and is in contact with the snail on the center arbor, which determines the number of strokes. The upper arm is indented with 12 notches, to act in concert with the *hawk's bill* in effecting the striking of the right number.

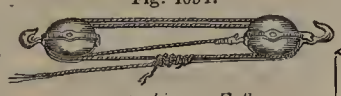
6. (*Lace.*) A certain length of lace-work, counted perpendicularly, and containing 240 meshes.

7. (*Nautical.*) *a.* A frame of wood with belaying-pins, or a row of blocks for fair-leaders, or a row of sheaves for reeving the running-rigging.

b. A frame with holes for round-shot.

c. A box in which the halyards are coiled away.

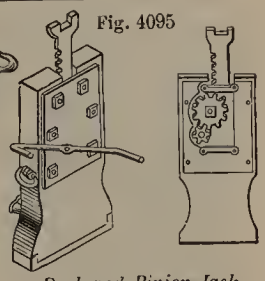
Fig. 4094.



Racking a Fall.

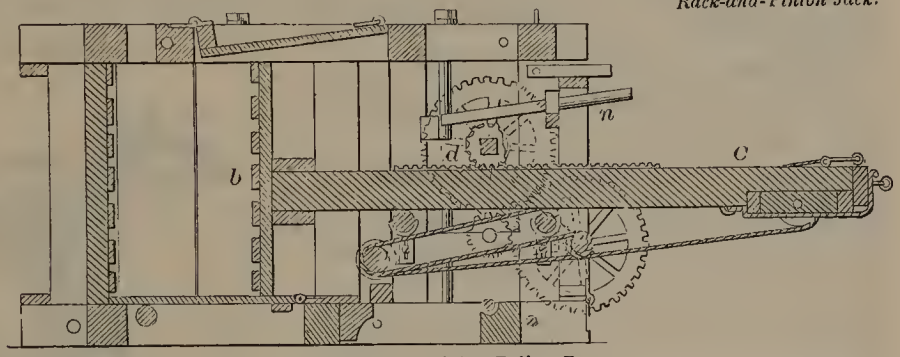
d. To *frap* or *seize* a *fall*. That is, to bind together

Fig. 4095



Rack-and-Pinion Jack.

Fig. 4096.



Rack-and Pinion Baling-Press.

two ropes of a tackle to retain it at a tension and prevent the ropes reeving back through the blocks.

Rack-and-pin'ion Jack. A lifting-jack, in which a rack and pinion is employed for gaining power. In the example, a pinion turned by a two-armed crank engages a gear-wheel fixed on the same shaft with a pinion meshing with the rack. Greater power may be obtained by increasing the number of wheels in the train or the difference of their radii.

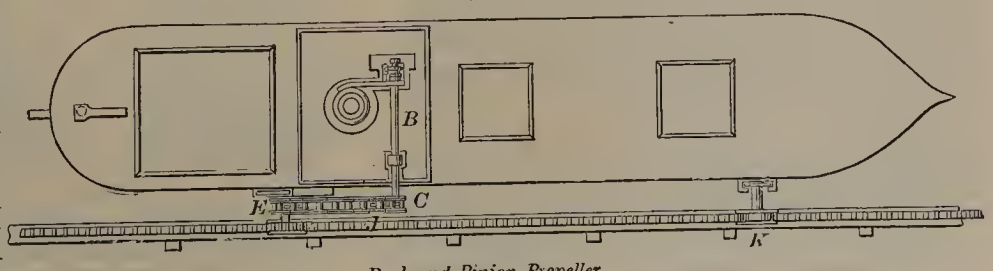
Rack-and-pin'ion Press. In this the force is transmitted, as the name indicates, through a pinion to a rack which is connected with the follower. In the faster movements of the follower, during the return-stroke, the gearing acts directly on the rack-beam; but during the heaviest compression the gearing operates through a windlass and rope.

A sliding pinion *d* operated by shifting lever *n* is the means of direct motion of the rack-beam *C*, when retracting the follower *b*.

Rack-and-pin'ion Pro-pel'ler. In order to obviate the inconveniences attending the use of horse-power and the injurious action of the ordinary paddle-wheel or propeller on the banks of canals, various devices in which wheels actuated by a motor on board the boat engage a continuous rack or rail at or above the canal bank, have been proposed.

Fig. 4097 shows one contrivance. A shaft *B*, driven by the engine, turns a cog-wheel *C*, connected by an endless chain with the spur-wheel *E*, on whose shaft is a pinion meshing with a rack *J* on the canal-bank. The bearings of the shaft *B* move freely in a vertical direction, so as to correspond with the variable immersion of the boat depending on the amount of her cargo. The boat is maintained in line with the con-

Fig. 4097.



Rack-and-Pinion Propeller.

tinuous rack by a roller *K* having flanges, which hold thereto while passing over the teeth. This also has vertical self-adjustment.

Rack-cal'i-pers. Calipers whose legs are opened and closed by rack-and-pinion motion.

Rack-com'pass. A joiner's compass, with a rack adjustment.

Rack'et. 1. A stringed battledore.

2. A snow-shoe.

3. A wooden sole for a man or horse to support the body when treading on soft or swampy ground.

Rack'et-wheel. A wheel toothed to receive a click or pawl. A *ratchet*-wheel.

Rack-hook. (*Horology.*) A device in the striking part of a repeating clock, which successively engages the teeth of the *rack* when the hours are struck. The *gathering-piece* or *pallet*.

Rack'ing. 1. (*Mining.*) Washing impurities from the ore.

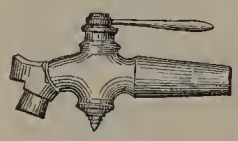
2. (*Nautical.*) Seizing two ropes together by a number of cross-turns. Spun yarn is used for *seizing*.

3. Decanting wine from the lees in a cask, after fermentation or fining.

Rack'ing-can. (*Metal-working.*) A can filled with sour beer, in which wire is steeped before *drawing*.

Rack'ing-cock. A form of faucet used in the cellar for racking off wines or ale.

Fig. 4098.



Racking-Cock.

Rack-rail. One laid alongside the bearing rails of a railway, and having cogs into which meshes a cog-wheel on the locomotive.

Blenkinsop's English patent, 1811. This had a toothed rail laid down on one side of the railway, from end to end. A cog-wheel was rigged out from the locomotive so as to engage with the rack and propel the train. It was at that time supposed that the adhesion of the driving-wheels to the track would not be sufficient under ordinary circumstances to enable the locomotive to draw the train. See LOCOMOTIVE, Fig. 2984.

Chapman, in 1812, substituted four pairs of drivers connected by gearing, so as to multiply the frictional contact.

Snowden, in 1824, had a hollow trunk between the two rails and depressed below the surface. On one side of this trunk was a rack, and the trunk itself had rails traversed by a carriage, which the inventor termed the "mechanical horse." On the horse was a vertical shaft with a horizontal cog-wheel at its lower end gearing into the rack, and a bevel-wheel above engaged by a similar wheel on the front of the locomotive, and driven by the engine. As the wheel on the locomotive rotated, the upright shaft conveyed motion to the cog-wheel beneath, and this acting on the rack drew along the mechanical horse and the train connected thereto.

Easton's English patent, 1825, specifies a central rack, placed between the two rails, and a toothed wheel on the locomotive. Guide-rollers bear laterally against the smooth sides of the central bar, in order to keep the carriages from swerving from the track.

The rack-rail is now only to be found in some forms of inclined-plane railways. See also CENTER-RAIL.

Rack-saw. A saw with wide teeth.

Rack-tail. (*Horology.*) A bent arm connected with the toothed segment-rack, by which the striking mechanism of a repeating clock is let off. It has a pin on its end, which falls into that one of the 12 notches of a snail on the star-wheel whose depth and position relative to the center of the star-wheel allows the rack to turn a number of teeth corresponding to the hour which is to be struck.

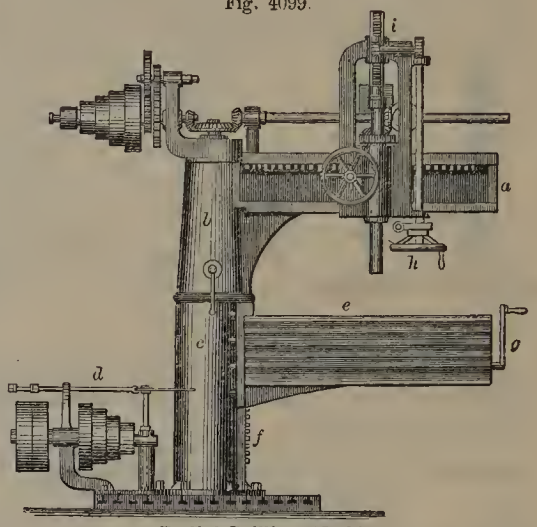
Rad'dle. 1. (*Nautical.*) Interlacing yarns to make flat gasket.

2. (*Weaving.*) A bar with upright pegs, used by weavers to keep the threads in place when winding the warp on to the beam.

3. An iron bar with an end bent at right angles, used by puddlers in stirring the iron in the furnace, and also in making up the balls for the tilt or squeezer. A *rabble*.

Ra'di-al Drill'ing-ma-chine'. An upright machine, designed for drilling a series of holes without changing the position of the work. In Thorne, De Haren & Co.'s, the arm *a* carrying the drill and its gearing is rotatable on the collar *b* surrounding the upper part of the fixed post *c*, on which are the driving-pulleys. The counter-shaft is at the base, and the belt by which they are driven is changed from the loose to the fast pulley and *vice versa* by

Fig. 4099.



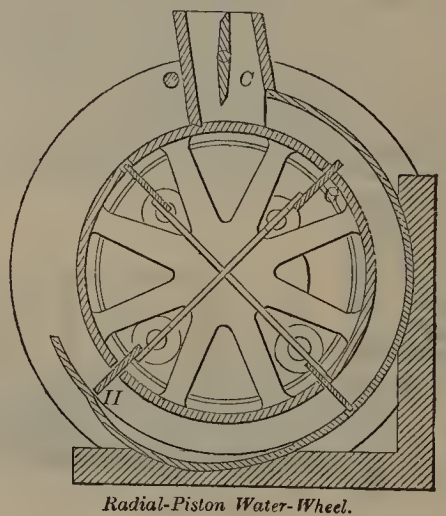
Radial Drilling-Machine.

the belt-shifter *d*. The table *e* is slotted at top and sides, and can be raised or lowered to suit the work, by a pinion working in the rack *f* and operated by the crank *g*.

The drill may be traversed back and forth on the arm *a* by a rack and pinion, and is provided with automatic changeable feed-gears; or the feed motion may be controlled by the hand-wheel *h* through a worm on its shaft, which gears with a worm-wheel whose shaft carries a pinion meshing with the feeding-rack *i*. See also HORIZONTAL LATHE; BORING-MACHINE; DRILL.

Ra'di-al-pis'ton Wa'ter-wheel. One having floats which are projected from the periphery against the breasting. The wheel receives its water a little past the meridian, where the sliding pistons *G H*

Fig. 4100.



Radial-Piston Water-Wheel.

begin to protrude to receive the force of the water admitted through the gate *C*, and before the arm becomes vertical; it extends all the way to the inner periphery of an apron which confines all the water behind. The sliding arms have friction-rollers to facilitate their movement, which is directed by an interior arrangement of cams.

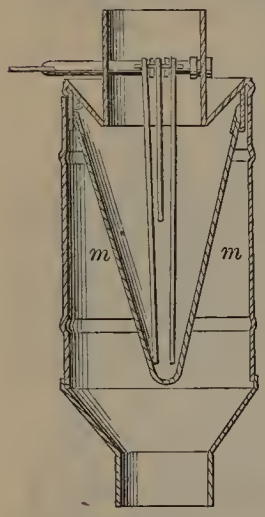
Ra'di-al Plan'ing-ma-chine'. (*Wood-working.*) A machine for chamfering or cornering the edges of timbers. It has a conical cutter, which ordinarily chamfers the edge to an angle of 45°. A pair of such cutters on an axis, at a regulated distance apart, to adapt the machine to given dimensions of timber, will chamfer both edges at one operation.

Ra'di-a'tor. (*Heating.*) A chamber or drum in an apartment, heated by steam or hot air and *radiating* warmth into the apartment.

It may be placed above a fireplace, stove, or furnace, and be heated by the volatile products of combustion on their way to the chimney; or it may form a part of a steam circulation, deriving its heat by steam-pipes from a boiler. See HEATING-APPARATUS.

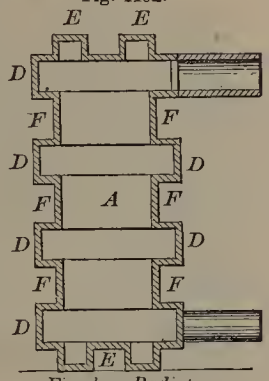
In Fig. 4101 segmental wings *m m* forming an inverted cone are arranged in a stove-pipe drum, and adjusted by links or rods connecting with a crank. When opened, the products of combustion pass freely through the drum, and when closed they flow

Fig. 4101.



Stove-Drum.

Fig. 4102.

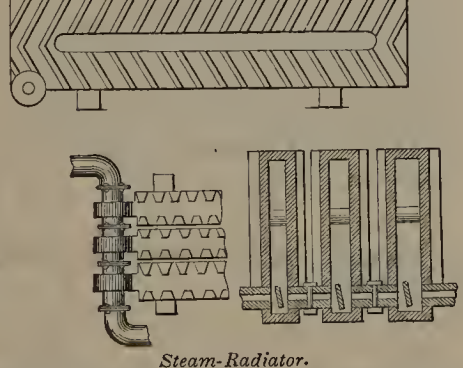


Fireplace-Radiator.

through a narrow opening between the base of the cone and the case of the drum.

In Fig. 4102, the chamber *A* is made of cast-iron or other suitable material, with alternate projections

Fig. 4103.

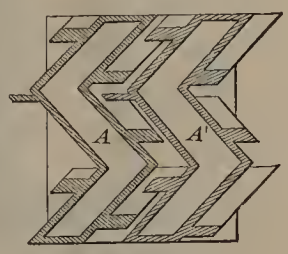


Steam-Radiator.

D E and recesses *F* placed within the fireplace. A pipe at the bottom communicates external air to it, and from the top a pipe leads off the heated air as desired.

In Fig. 4103 the radiator is made in sections, each of which has a circuitous passage, and at one end is associated with a series of similar sections, their coincident openings making a continuous pipe with inclined plates to direct the flow into the chambers consecutively. The projections on the outside of the heater force the air into a tortuous course and increase the radiating surface.

Fig. 4104.



Steam-Radiator.

Fig. 4104 has a number of steam-heated hollow sections *A A'* having a zigzag form; the spaces intervening between the sections are air-passages made tortuous by inclined ribs projecting from the sections.

Ra'di-om'e-ter. A *fore-staff.* An instrument for taking the altitudes of the celestial bodies.

Ra'di-us. The movable limb of a sextant or other angular instrument.

Ra'di-us-bar. (*Steam-engine.*) *Radius-rod. Bridle-rod.* One of two duplicate rods, which, pivoted at one end to a beam and at the other to one of the hanging links, serve in the parallel motion of Watt to guide the piston-rod in a vertical direction by counteracting the vibratory motion communicated by the beam. See PARALLEL MOTION.

Ra'di-us-rod. (*Steam-engine.*) One of the guiding-rods in a parallel motion, jointed to the connecting-links, to counteract the vibratory motion communicated by the beam, by guiding the links so that the head of the piston-rod may reciprocate in a line sensibly straight.

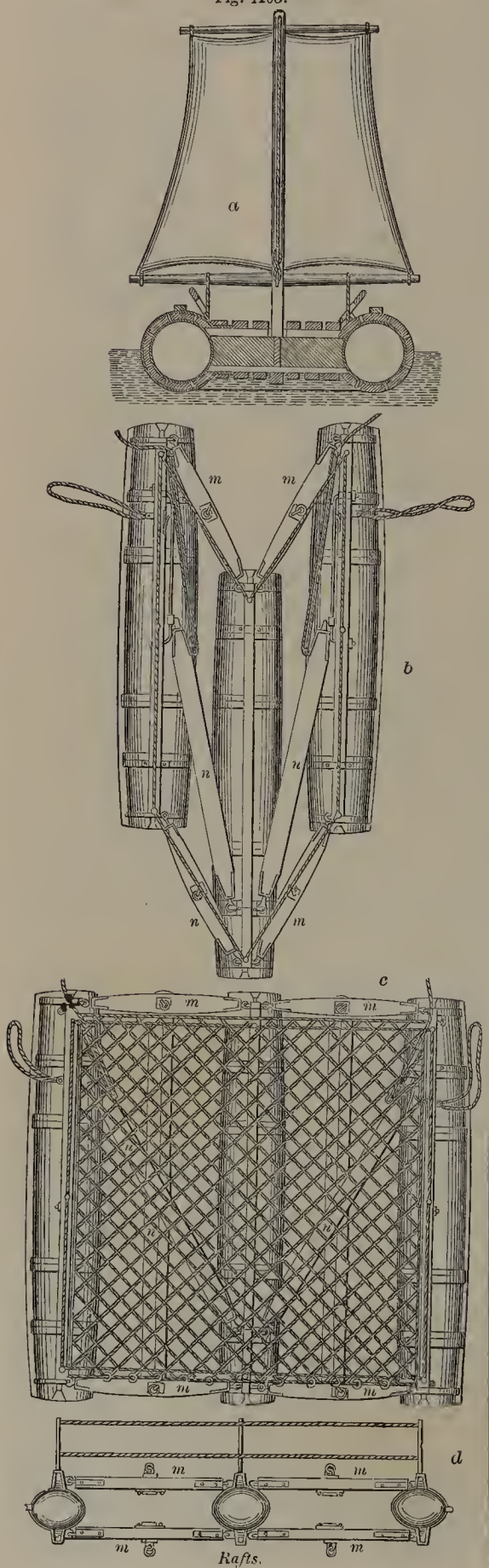
Raft. A structure depending for its capacity for carrying persons or freight upon the lightness relatively to water of the materials of which it is composed. Excepting as to lumber-rafts, which are made up of logs and sawed lumber attached together in order to be floated to a shipping port or to market, rafts are usually a device made and used in an exigency; such are those made in the emergency of shipwreck, among the most notable instances of which is the loss of the French frigate "Medusa."

This melancholy event occurred in the year 1816. The "Medusa," having on board, in addition to her crew, a detachment of soldiers designed to garrison the fort at St. Louis River, Senegal, Africa, which had been given up by the English under the treaty of the preceding year, struck unexpectedly on the Arguin bank a dangerous shoal, lying some twelve or fifteen leagues from the African coast, in latitude 20° north; a large raft was hastily constructed by lashing together such spars and other materials as were at hand, and on this the majority of the persons on board were embarked, the boats of the ship sufficing for only a comparatively small number. When all were on the raft it was submerged until the water came nearly up to their waists. There was consequently little room for provisions or water; a small quantity of bread, wine, and brandy was, however, taken.

It had been arranged that the boats were to tow the raft to shore, which it was supposed could be done in two or three days, but during the night succeeding the disaster, they inhumanly cast off the towing lines, leaving those on the raft to their fate. A frightful scene of disorder and bloodshed then ensued. Maddened by thirst, rendered desperate by the appalling hopelessness of their situation and by the liquor which some of them had succeeded in surreptitiously obtaining, all discipline was lost, and part made a combined attack upon the rest, with the object of forcing them overboard. This riot was finally quelled by the captain, who had remained on the raft, with the assistance of some of the more self-possessed portion of the crew and soldiers; but when day dawned, it was found that one third of their number were missing, having been killed in suppressing the disorder, washed off the raft, or thrown overboard by others.

Successive frays occurred, resulting in loss of life among the remainder; more were washed off by the sea, and many died

Fig. 4105.

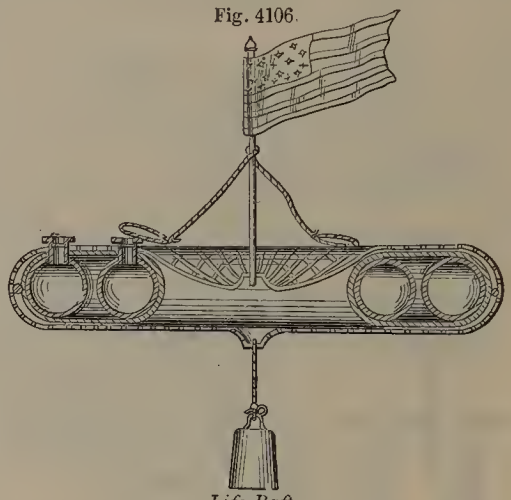


Rafts.

from thirst and exhaustion. When, after drifting for nearly two weeks almost within sight of land, the raft was finally discovered by a passing vessel, scarce a half-score of survivors remained.

Rafts are made of materials usually accessible on shipboard, spars lashed together by ropes, the flotative power being increased by empty casks lashed in the structure. When made and furnished as a part of the ship's equipment, they are constructed with pontons, as in the illustrations annexed. In the upper one (*a*), two pontons are united by a frame on which is a grating for the passengers and means for stepping and supporting a mast. The other figures rep-

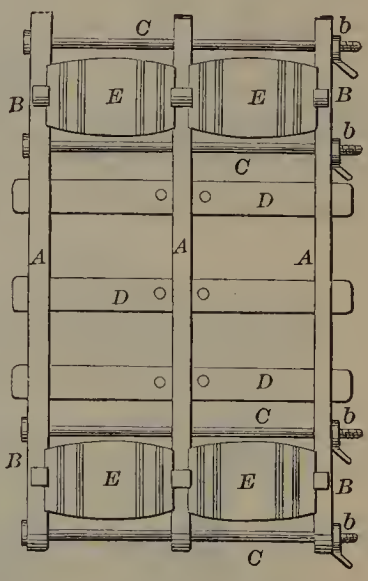
Fig. 4106.



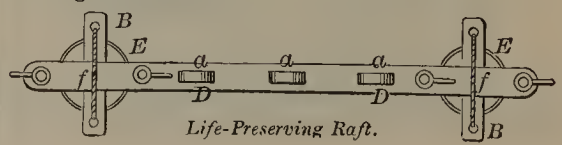
Life-Raft.

resent a raft in different conditions. *b* is a top view, showing the raft in a partially collapsed condition, the three pontons being united by hinged bars *m*, which are operated by tackle, so as to extend the structure into the form shown in the view *c*. The bars *n* in this latter condition form diagonal braces, while the bars *m* are transverse. The view shown at *d* is a transverse vertical section, and exhibits the stanchions and ropes, which form a protection against persons or things falling or being washed overboard. The floor of the raft is a rope netting. The raft is carried in a collapsed condition for compact stowage, and is more readily launched in that less bulky condition; after it is in the water it is brought into working shape by the purchases. See LIFE-BOAT; LIFE-PRESERVER.

Fig. 4107.



The raft (Fig. 4106) is of this description, consisting of inner



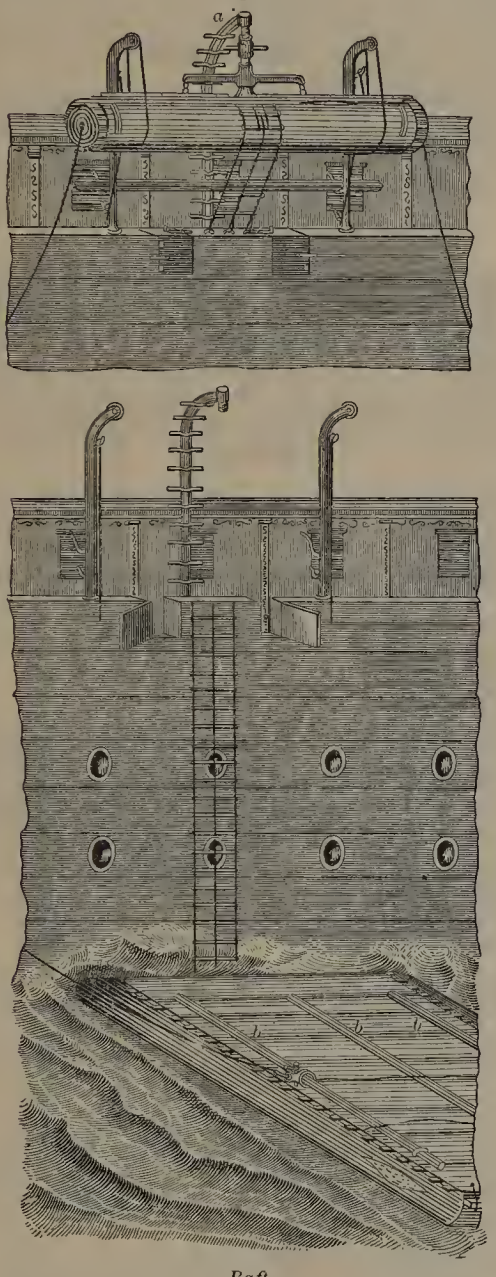
Life-Preserving Raft.

and outer india-rubber tubes, which are separately inflatable, and surrounded by a connecting network, from the lower part of which a weight may he suspended to prevent capsizing.

The frame of the life-preserving raft (Fig. 4107) is composed of side-bars *A A*, held together hy screw-threaded rods *C*, having tightening-uuts *b* at their ends, and by cross-hars *D D* tenoned to fit mortises *a a* in the side-hars; standards *B B* are grooved to receive the chimes of barrels *E* halved into the side-bars, and have holes through which lashing ropes are passed. The detached parts are stowed in any convenient part of the ship, so that they may he immediately assemhled in case of emergency. Special barrels may he provided, or ordinary water-tight casks may be used.

The raft (Fig. 4108) consists of a large air mattress, having a number of wooden slats on its upper side, aud covered with a

Fig. 4108.



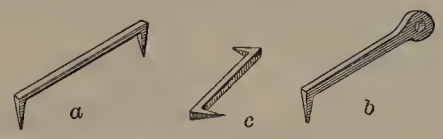
Raft.

canvas deck. It is ordinarily kept rolled up and suspended from a pair of davits. For use it is unrolled by casting off the end supporting ropes and inflated through the hollow pillar *a* from a reservoir below, kept constantly full of compressed air. After being launched it is stiffened by pushing iron rods through the three flexible tubes *b b b* longitudinally to the mattress.

Raft-bridge. (*Hydraulic Engineering.*) A bridge of expediency, where rafts are used as pontons to support the beams and the track. The rafts are anchored by guys, shore-ropes, or moorings, according to the nature of the case. The general construction of the roadway is similar to that of the PONTON-BRIDGE (which see).

Raft-dog. (*Lumbering.*) A bar *a*, with bent-

Fig. 4109.



a, Raft-Dog. *b, Raft-Hook.* *c, Raker.*

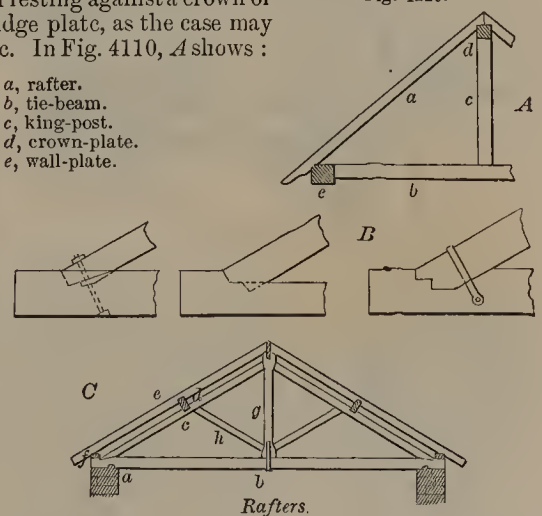
over and pointed ends, for securing logs together in a raft.

A *dog-hook b* is for securing a rope to a log or raft.

In the lumber regions, trees, after being cut down and deprived of their limbs, are hauled to the nearest available stream and deposited close to the water's edge. This work is done in winter, as the logs are then easily hauled over the snow-covered ground, and deposited where they can be readily floated off when the spring freshets occur. Dogs and similar appliances are used to launch such logs as are not floated by the stream, and when all are fairly under way the timber-cutters follow the run of logs down to push off any which may become lodged, or, in case they become jammed in a gorge, to disentangle the mass, — often a difficult and perilous operation. On arriving at the point where they are to be converted into squared timber or boards, as the case may be, they are intercepted by a boom stretched across the stream, and are caught and arranged according to ownership hy men stationed there for the purpose, the logs belonging to each proprietor having heen marked so as to be readily identified.

Raft'er. (*Building.*) One of the pieces of timber which follows the slope of the roof, and to which is secured the lath into which the shingle or slate nails are driven. The rafter, in one or more lengths, extends from the eave to the ridge of the roof; at its lower end resting on the wall-plates, and at its upper end abutting upon a corresponding rafter rising from the opposite side of the roof, or resting against a crown or ridge plate, as the case may be. In Fig. 4110, *A* shows:

Fig. 4110.



a, rafter.
b, tie-beam.
c, king-post.
d, crown-plate.
e, wall-plate.

Rafters.

The foot of the rafter is mortised or otherwise secured to the tie-beam, as shown at *B*.

In some roofs heavy scantling are framed between the tie-beam and shoulders on the king-post, and are called *principal rafters*. The ordinary rafters then rest upon a pole-plate, purlin, and ridge-plate. See KING-POST.

Rafters, though all performing the same general duty, have specific names according to their particular functions, as, —

Arched rafter. One of segmental form in an arched roof.

Auxiliary rafters are timbers framed beneath the *principal rafters*, to support them. They are known also as *cushion rafters*, or *principal braces*.

A *binding* rafter is one which acts as a tie. *Chief* rafter, a *principal* rafter.

Common rafters are those on which rest the sheeting or lathing, to which the slates or shingles are secured. *C* (Fig. 4110) shows a mode of forming a king-post truss : —

a, wall-plate.
b, tie-beam.
c, principal rafter.
d, purlin.
e, common rafter.
f, pole-plate.
g, king-post.
h, purlin-post or strut.

Curb rafter. One of the pair forming the truss in an ordinary curb roof.

Hip rafter. That which occupies the angle of a *hip roof*, and into which the upper ends of the short rafters of the sides and ends are framed.

Intermediate rafter. One between principals or common, to strengthen at a given place.

Jack rafter. A short rafter let into the hip rafter at the angles of a hip roof.

A *principal rafter* is one of a pair in the sides of a truss which have the slant of the roof and support the purlins on which the common rafters rest.

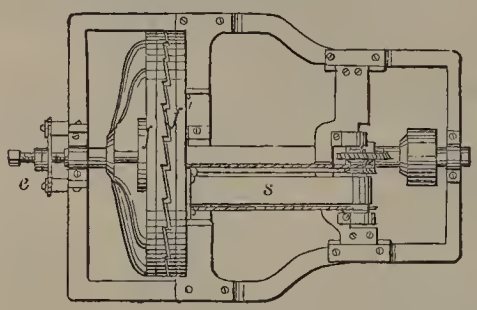
Raft-port. (*Shipbuilding.*) A square port in the sides of a vessel for passing cargo.

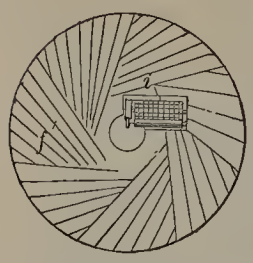
Rag-bolt. A bolt having backwardly projecting barbs or jags to prevent it from being easily withdrawn after having been driven. A *barbed* bolt.

Rag-car′pet. A carpet with a cotton or hempen chain and a filling or weft of strips of rags or cloth, sewed together end on end.

Rag-cut′ting Ma-chine′. (*Paper-making.*) A machine for comminuting rags preparatory to pulping. Fig. 4111 has a rotating disk *f* with cutters

Fig. 4111.





Rag-Cutting Machine.

on its face, and a stationary disk *f′* with an aperture through which rags placed on the endless apron *s* are fed in between the two to be operated on by means of a roller *i*; the two disks may be separated for cleaning, etc., by means of a screw device *e*. See RAG-ENGINE; PULPING-MACHINE; PULP-GRINDER.

Rag-dust′er. (*Paper-making.*) A machine for removing the dust, etc., from rags previous to washing them.

Debit's (1829) is a wire-cloth cylinder having a rotating axis provided with spokes.

Burt's (1836–38) has a wire-cloth revolving cylinder containing rotating longitudinal shafts armed with beaters.

In Carriel's (1831) the wire-cloth cylinder in which the rags are placed has exterior longitudinal radial wings to carry off the dust.

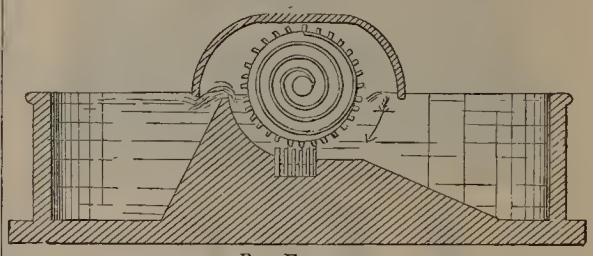
Rag-en′gine. (*Paper-making.*) The machine in which rags are partially comminuted.

Until the present century, rags were reduced to pulp for paper by means of mashing and incipient fermentation. Stamping-mills were then introduced, but the iron stamps in oak mortars are stated to have been so slow that 40 pairs working 24 hours would only reduce 112 pounds of rags. The rag-engine was invented in Holland, about 1750, but it was many years before it reached England.

It consists of an oblong trough containing one or more rotating cylinders having cutters on their peripheries, which work against similar cutters fixed in the bottom of the trough, which is curved to correspond with the cylinder and form a partition over which the stuff passes and repasses during the process of comminution.

Fig. 4112 has a spiral flange on each end of the cylinder, to prevent the collection of rags around

Fig. 4112.



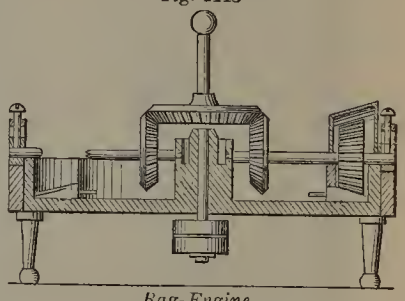
Rag-Engine.

the cylinder and avoid choking; its action tends to throw off the pulp from the center to the circumference.

Fig. 4113 has an annular stationary trough with knives in the bed and conical rollers, which rotate above. The place of the roller on the left is vacant.

Another form of engine has a series of circular saws on a mandrel operating in the notched end of a feed-board. (Clarke and Albertson, 1838.)

Fig. 4113



Rag-Engine.

Still another form has a drum armed with prongs revolving in a cylinder with internally projecting bars.

Rag′ging. 1. (*Metallurgy.*) The rough breaking of ore to reduce its size and enable the rejection of the poorer portions.

2. Also termed *straggling*. Rough-dressing the surface of a grindstone to clear its face of imbedded metallic particles. The stone is turned as usual, while a piece of ¼-inch soft iron is worked against it, as if turning off the stone, a rocking motion being imparted to the tool.

The same plan is adopted in evening the face of a stone which has worn into holes, owing to inequality of hardness in its various parts.

A better plan is to hang two stones so that the surface of each may turn against that of the other, thus preventing the formation of ridges and hollows.

Rag′ging-ham′mer. (*Metallurgy.*) A steel-headed hammer, weighing 6 to 8 pounds. It is used in rough-dressing ores.

Rag-wheel. Another name for the SPROCKET-

WHEEL (which see). The periphery has pins or projecting portions, which are caught by the links of the chain.

Rag-work. (*Masonry.*) Wall laid with undressed flat stones of about the thickness of a brick, and leaving a rough exterior from whence the name is derived.

Rail. A horizontal or inclined piece of wood or metal connecting two posts or uprights; as, —

1. (*Joinery.*) *a.* One of the pieces connecting the *posts* of a bedstead. Known as *head-rail*, *foot-rail*, *side-rail*, according to position.

b. A horizontal piece in a frame, as of a door, sash, or other paneled work. In a door, the *rails* are mortised into the *stiles*, and together with the latter surround the *panel*. In *sash*, the *panel* is absent or may be said to consist of a pane or panes of glass.

c. The upper piece into which the balusters of a stair or balustrade are mortised.

2. (*Shipbuilding.*) *a.* The top of the bulwarks proper; that part continued around the stern is the *taffrail*. When it crowns the top-gallant bulwarks it is the *top-gallant* rail.

b. A curved timber extending from the bow of a ship to support the knee of the head.

3. (*Railway.*) The bar supported on sleepers and affording a track for car-wheels.

The history of the *rail* commences with paving and tramways, the latter being smooth stone blocks for the wheels on each side of a rougher track for the horses. These ways came to be made of timbers, and eventually of iron, being at the first but flat strips laid on continuous sleepers, but eventually of bars which are sufficiently strong to span the distance between transverse sleepers. The work of improvement began in earnest in the English collieries.

Wooden railways were laid at Newcastle in 1602. These were laid parallel and imbedded in the ordinary road. "The rollers of the carts were made to fit the rails." (NORTH, 1676.) After a while the rails were laid on cross-ties and pinned thereto.

In 1716 flat plates of malleable iron were nailed to the wooden rails. (*a*, *flat rail.*)

In 1767 the Coalbrookdale works laid down flat cast-iron rails.

In 1776 cast-iron rails, with an upright flange, were laid on wooden sleepers and used at the Duke of Norfolk's colliery, near Sheffield. (Carr's patent, *b*.) They were spiked down. The flange was put on the rail before it was put on the wheel.

In 1789 Loughborough's cast-iron edge-rail, with flanges on the wagon wheels.

In 1792 stone bearers were substituted for wooden sleepers at Little Eaton, in Derbyshire.

Wrought-iron bars, two or three inches in thickness, spiked to longitudinal sleepers, were then used in connection with flanged wheels.

Wyatt's cast edge-rail of oval section (*c*) was then used in connection with grooved wheels at Penrhyn slate quarries, in 1800.

Jessop used this rail in 1789, and added the chair (*d*), a block of iron slotted to receive the ends of adjacent rails. The wheel had a tread of 2½ inches, and a flange to keep it on the rail. The sleepers were of wood.

Woodhouse's hollow rail (*e*), with a channel for the rounded edge of the wheel, 1803.

The fish-bellied rail at Penrhyn, 1805.

Blenkinsop's rack-rail (*f*), 1811. See Fig 2984, page 1344.

A square-bodied cast rail (*g*), 1810.

Losh and Stephenson's flanged rail (*h*), 1816. This was a lapping continuous rail.

Hawk's cast-iron face upon a wrought-iron base, 1817.

Birkenshaw's malleable face upon a cast base, 1820.

Birkenshaw, of Bedlington, Durham, invented the rolled rail; the iron, while hot, being passed between grooved rollers of the required pattern (*i j k l*).

m n o p are respectively the Spanish, Marseilles, Strasburg, and Great Western (England) patterns.

q, Durham and Sunderland, England.

r, Berlin and Potsdam, Prussia.

s, London and Blackwall, England.

t, Manchester and Birmingham, England.

u, Saint-Etienne to Lyon, France.

v, Wilmington and Susquehanna, United States.

w, Great Western (Old), England.

x, London and Croydon, England, which first dispensed with longitudinal sleepers and chairs.

y, Morris and Prevost, England.

z, Birmingham and Gloucester, England.

a', London and Birmingham, England.

b', London and Brighton, England.

c', Midland counties, England.

d', contractor's rail.

e', street car rail.

f', locomotive street-rail.

g', continuous rail.

h', tubular rail.

j', King's rail, with steel cap.

k', Potter's rail, with steel facing rolled in.

l', Hymer's rail, with a steel upper section, iron foot, and fish-plates.

m', Asheroft's rail, with a steel tread and double foot.

n', Jones's rail, with a steel tread and forked foot.

o', Booth's rail, with an overlapping steel tread-plate See FAGOT; Fig. 1914, page 823.

p', Losh's fish bellied rail and chair (1816); the rail fastened with keys.

q' Brunton and Shield's rail and chair.

r', English rail and chair, 1840.

s', Samuel's cast-iron sleeper.

t', Barlow's rail (English).

u', tubular socketed rail.

v', Seaton's saddle-rail.

w', elastic rail.

x', Pierce's rail, on high standard.

y', Greave's pot-sleeper.

z', Reynold's continuous bearing.

a'', Stephenson's chair and rail.

b'', Adams's rail.

c'', Button's rail, with steel top.

d'', Brooks's steel-capped rail.

e'', Lewis's rail.

f'', Hanmer and Grim's steel-topped rail.

g'', Hagan's rail

h'', Chamber's rail, on elastic webs.

i'', Robinson's double rail.

j'', Pierce's rail.

k'', Peckham's rail.

l'', Perkins's rail.

Fig. 4114.

Railway-Rails.

m'', Shephard's steel-top rail.
n'', Day and Mercer's rail.
o'', Dwight's rail.
p'', Zahn's rail.
q'', Johnston's rail.
r'', Stepheus aud Jenkins's rail.
s'', Sauborn's tubular rail.
t'', Sanborn's rail.
u'' Angle's L-rail on continuous sleeper.
v'', Dean aud Colemau's street-car rail.
w'', rail and sleeper, for the East Indies. The sleeper is bent from a plate of wrought-iron to resist the attacks of insects which destroy wooden sleepers.

Parkin's vitrified sleeper, patented in England in 1835, consists of hard sleepers of molded aud baked blocks laid in continuity, tongues aud recesses on adjacent blocks serving to lock them together. A timber strip was interposed between the row of blocks and the rail.

Grime's Euglish pateut, 1831, specified a hollow rail charged with steam from stationary boilers at intervals of two or three miles, aud intended to keep theu clear of ice and snow.

The first steel rail was made in 1857, by Mushet, at the Ebbw-Vale Iron Co.'s Works in South Wales. It was rolled from cast blooms of Bessemer steel and laid down at Derby, England, and remained sixteen years, during which time 250 trains and at least 250 detached engines and tenders passed over it daily. Taking 312 working days in each year, we have the total of 1,252,000 trains and 1,252,000 detached engines and tenders which passed over it from the time it was first laid before it was removed to be worked over.

The substitution of steel for iron, to an extent rendered possible by the Bessemer process, has worked a great and abiding change in the condition of our ways, giving greater endurance both in respect of wear and in resistance to breaking strains and jars.

Two steel rails of twenty-one feet in length were laid ou the 2d of May, 1862, at the Chalk Farm Bridge, side by side with two ordinary rails. After having outlasted sixteen faces of the ordinary rails, the steel oues were taken up and examined, and it was found that at the expiration of three years and three months, the surface was evenly worn to the extent of only a little more than a quarter of an inch, and to all appearance they were capable of enduriug a great deal more work. These two rails had, during the period of little more than three years, been exposed to the traffic of 9,550,000 eugines, trucks, and earriages, and 95,577,240 tons. It is an amount of traffic equal to nearly ten times that which destroyed the Great Northern rails in three years. The result of this trial was to induce the London and Northwestern to enter very extensively into the employment of steel rails.

Railway rails are made of puddled steel at the Höerdér Iron and Steel Works, Westphalia. The process consists in bringing a number of balls together to a heavy hammer (say a 12-ton steam-hammer), which welds them together into a homogeneous bloom. The faces of the hammer and anvil are hollow, so as to keep the metal together, and the bloom is sent at the same heat to the rolls.

A number of puddled steel balls are welded into one, in a furnace, as a single puddled ball is not large enough to make a rail.

Weight. The tendeney to inerease the stability of the track by inereasing the weight has led to a deterioration in the quality of the rail, and the lamination and wear have more than compensated for any immobility due to weight.

Mr. Holley, after the great wear endured by the 45-pound rails made by the Ebbw-Vale Company for the Philadelphia and Reading Railway Company, in 1837, and comparing the loug life of the 45-pound rail with that of the 64 and 68 pound rails whieh replaced them, goes into a consideration of the substitution of lighter for heavier rails ou many of the English railways.

"The true eourse," he remarks, "is in the use of the best of iron in moderately light rails. The cost per ton is increased but by a comparatively small amount, while the durability may be doubled. One advantage of a light rail is, that its very size ensures more work beiug expended upou it."

The reduction in weight has heen in the head and stem of the rails. The same depth is preserved, about five inehes.

Length. Rails are made in England from 15 to 21 feet long, the latter being usual. One railroad is said to be furnished with rails of 30 feet. A Welsh rolling-mill furnished a Barlow rail 52½ feet long, but it was done as a trophy. Wrought-iron rafters were rolled at Phœnixville, Pa, for the United States Capitol, having a length of 51 $\frac{1}{6}$ feet. Iron plates for the Collins steamers were rolled at Troy, N. Y., 60 feet in length, from piles of 700 pouuds weight.

Depth. The depth of the most lasting English rails is stated to be from 4½ to 5½ inches, mostly 5 inches.

The Sandwich rail is made with a depth of 8 inches, the web being very deep, and from ¼ to ⅜ inch thick. It is prevented from lateral deflection by side sleepers which clamp the web, and the head of the rail rests on the side supports.

The great depth saves the rail from vertical deflection, and the longitudinal sleepers preserve it laterally. The rail is *double-headed*.

A rail is an iron beam, and the stiffness is as the cube of the depth; the result being modified by the flanges.

Width. The width of rails is from 2¼ to 3 inches. The top has a curve of a radius of 5 to 5¼ inches.

Form. The resistauce of wrought-iron to extension and compression is as 90 of the first to 66 of the second. These proportions should therefore exist in a rail when it is not to be reversed.

"The life of iron rails of best quality has been fouud to be 35,000,000 tons over a double line, or 17,000,000 over each single rail, and many from the best makers stand only 5,500,000 to 15,000,000 tons, the greatest wear being in cuttings and tunnels where there is the least elasticity. The average life of an iron rail being 15,000,000 tons, or equal to 100,000 trains of 150 tons each, independently of the length of time of the traffic, the wear may be estimated as the 1-100000th part of the value of the rail each time a train goes over it; and if the value of a mile of iron rails he taken at $5,000, the wear would be 5 cents per train mile.

"On the Great Northern Railway, at Barnet, the life of an iron rail was 5 years, with 13,484,661 tons of fast trains, and 38,303,028 tons slow traffic. Steel rails were only half worn out with 95,577,240 tons traffic. As the life of an iron rail is but 1-6th of a steel rail, it must follow that a great excess of mechanical work, represented in destruction of the iron rails by the rolling stock, must ensue. Locomotive power depending mainly on the resistance to traction (due to the deflection of track and abrasion) costs 25 cents to 31 cents per train mile, and anything which will reduce this by 1-5th or 1-6th will soon effect a saving equal to the whole cost of the rails.

"On falling gradients, with the traffic, the wear is greatest, owing to the momentum acquired; on a falling gradient of 1 in 130, a mixed traffic of 62,899 trains, gross tonnage 12,451,784 tons, wore out the best samples of iron rails in 7¼ years; on a level, with a heavy all-one-way traffic, same description of rails required 203,122 trains, and 38,803,128 tons, to wear them out in 7¼ years.

"The destructive effects of high speed, with the same engine and everything similar, were such that the same rails required more than three times the traffic to wear them out at the lower speeds; and for equal quantities of traffic the wear of the rail is in the ratio of the square of the velocity (the matter in front compressed by the weight of the wheel is in proportion to the shortness of the time of passage, the resistance being as the square of the velocity).

"On mineral roads, with heavy up and down grades, with diminished speed up grade, and accelerated speed down grade, the wear and tear is considerably greater than if the same space is traversed at a uniform speed equal to the average speed.

"The wear of a rail placed upon a chair upon a tie was similar to the effect of pounding a rail upon an anvil, the end flattens into a fan shape, while, if suspended, being sustained by fish-plates, the hammering action of the train, being over a void, falls harmless on the ends of the rail." — *Engineering.*

Allowance for expansiou of joints of a 20-foot rail: —

At 100° Fah. place them in contact.	
90° Fah. at a distauce of	.016 iuch.
80° Fah. at a distance of	.032 "
70° Fah. at a distanee of	.049 "
60° Fah. at a distauee of	.065 "
50° Fah. at a distauce of	.082 "
40° Fah. at a distauce of	.098 "
30° Fah. at a distance of	.104 "
20° Fah. at a distance of	.131 "
10° Fah. at a distance of	.147 "
0° Fah. at a distance of	.163 "
—10° Fah. at a distance of	.179 "
—20° Fah. at a distauce of	.212 "
—30° Fah. at a distance of	.296 "

See under the following list, which iucludes other than railway rails: —

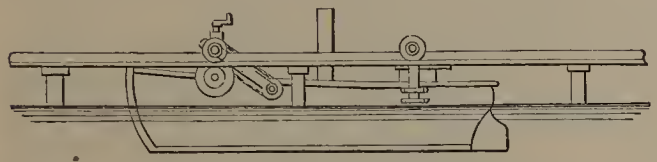
Barn-door rail.
Belly-rail.
Bridge-rail.
Capped rail.
Ceuter-rail.
Champiguon-rail.
Compouud rail.
Continuous rail.
Crossing-rail.
Double-headed rail.
Edge-rail.
False rail.
Fish-bellied rail.
Flange-rail.
Flat rail.
Foot-rail.
Frog.
Guard-rail.
Guide-rail.
Hand-rail.
Head-rail.
Hollow-rail.
I-rail.
Lock-rail.
Plate-rail.
Rack-rail.
Rail-coupliug.
Rail-guard.
Rail-jack.
Railway.
Railway-rail.
Saddle-rail.

Safety-way.
Sash-rail.
Side-way.
Slide-rail.
Splice.
Steel-headed rail.
Steel-topped rail.
Switch.
Three-headed rail.
Track-rail.
T-rail.
Tram-plate.
Tubular rail.
Wing-rail.
Wooden rail.

Rail and Trav'ers-ing-wheel Pro-pel'ler. A device for propelling canal-boats.

Fig. 4115 comprises a continuous rail supported by posts upon the bank, and its upper and lower

Fig. 4115.



Rail and Traversing-Wheel Propeller.

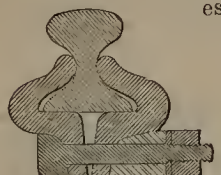
surfaces are traversed by wheels upon an arm extending from the boat, the wheel being rotated by a motor on board.

Rail-bend'er. (*Railway Engineering.*) An implement for bending or straightening rails, or for breaking steel rails to such lengths as may be required. It has two curved branches on which the rail rests, while a powerful screw or a plunger operated by hydraulic pressure is brought to bear against it at a point midway between them. The hydraulic form affords the greater power, and is more convenient and expeditious. Frequently called a JIM-CROW (which see). See also *E F*, Plate XXV.

Rail-chair. (*Railway.*) A socket for a rail, where it rests upon the sleeper. See RAILWAY-CHAIR.

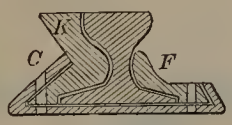
Rail-clamp. (*Railway Engineering.*) A device designed for firmly holding rails on lines of track so as to prevent any shaking motion. Scott's clamp truss-joint (Fig. 4116) is in two parts, the upper curved branches of which are caused to bind

Fig. 4116.



Rail-Clamp.

Fig. 4117.



Rail-Clamp.

the rail by means of a screw-threaded pin passing through their lower branches and a nut. See RAILWAY-CHAIR.

In Watkins's (Fig. 4117), the rail is held between a brace-key *K* and tightening-key *F*. These are drawn together to hold the rail, and at the same time secured to the sleepers by wedge-shaped spikes driven through them and through the flanged clamp *C*.

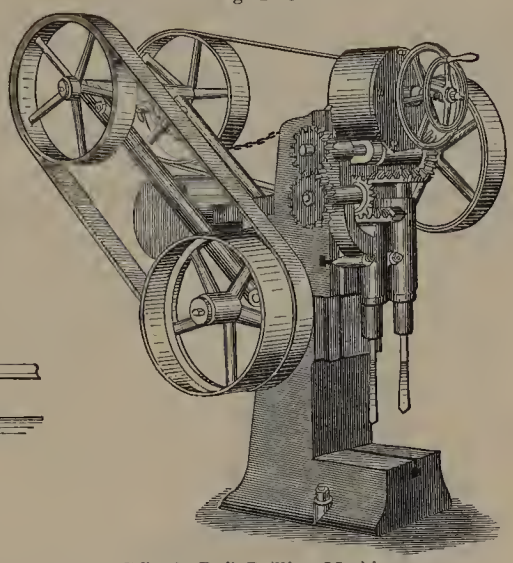
Rail-coup'ling. (*Railway.*) *a.* A bar which ties the two rails of a track together, to prevent spreading at critical points, switches, etc.

b. A fastening plate for the abutting ends of two rails in a track. A *rail-chair* sometimes acts as such.

Rail-drill'ing Ma-chine'. For drilling the holes near the ends of steel rails in which the fish-bar bolts are inserted.

The feed is positive and invariable, though slow, while a rapid rotation is given to the drill, this method being found more advantageous with steel than a comparatively slow rotation with quicker feed. The lubricant is animal oil.

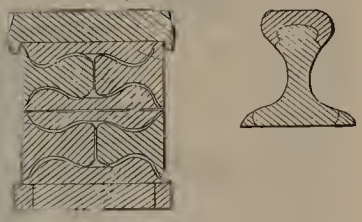
Fig. 4118.



Sellers's Rail-Drilling Machine.

Rail-fag'ot. (*Metal-working.*) The built-up mass from which rails are rolled to proper section and length. In Fig. 4119, the top and bottom plates are wider than the intermediate filling, which consists of two pairs of old rails, cut to length, laid on their sides, their treads in contact, with two B-plates between the pairs and one on top and bottom of the filling and next to the exterior plates. See PILE; FAGOT; BEAM.

Fig. 4119.



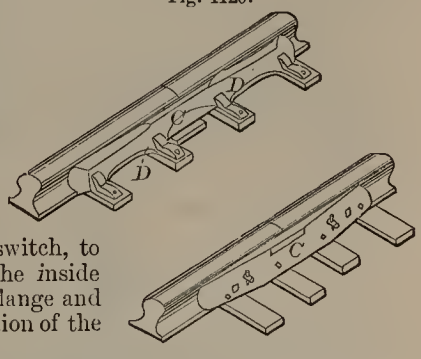
Rail-Fagot.

Rail-guard. (*Railway Engineering.*) A device for throwing aside obstructions on the track.

a. In England, the rail-guards are attached to the front of the frame of the locomotive, and reach down within about two inches of the rail, to catch and throw to one side any obstruction which may be on the rails.

b. In America, the *cow-catcher* or *pilot* is a substitute, and is somewhat efficient for the whole width of the track.

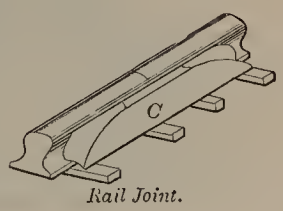
Fig. 4120.



c. A guard-rail, as at a switch, to bear against the inside of the wheel-flange and prevent deviation of the wheel.

Rail-jack. (*Railway Engineering.*) An apparatus for lifting railway rails to ballast beneath the ties and level the track. See TRACK-RAISER.

Rail-joint. A device for firmly holding the abutting ends of two adjacent rails. Different arrange-



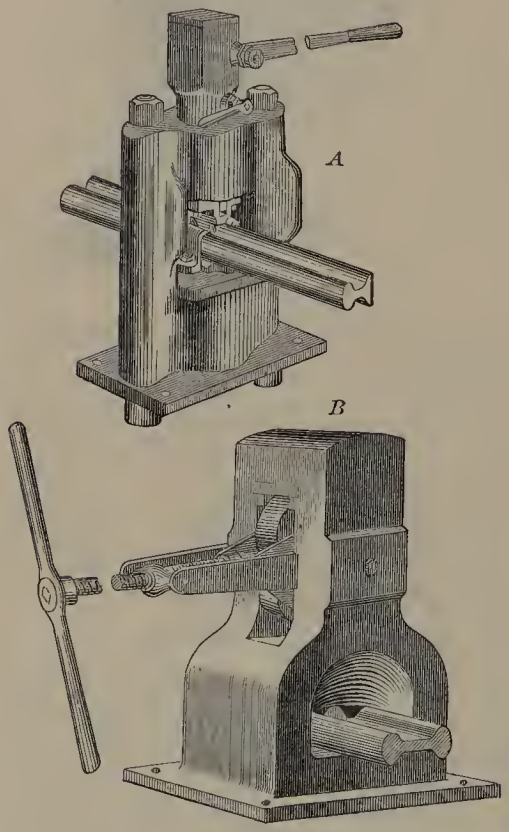
Rail Joint.

ments have been contrived for this purpose. Fig. 4120 consists of a fish-piece *C* of metal or wood plated with metal, sufficiently long to extend over several ties and held to the sleepers by the chairs *D D*. Bolts through the rails may be dispensed with.

Rail-post; Rail'ing-post. (*Building.*) A newel post for a staircase or balustrade.

Rail-punch. For punching the web of railway rails, etc. That shown at *A* is worked by hydraulic

Fig. 4121.

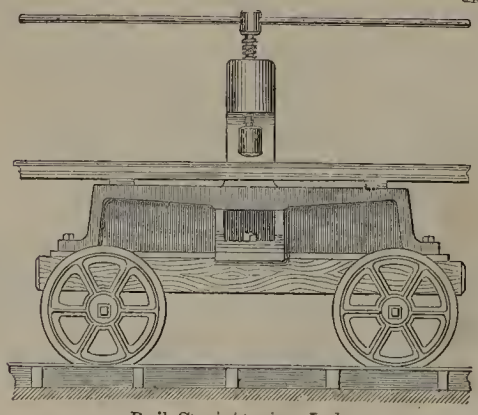


Rail-Punch.

pressure, being a slight modification of the PUNCHING-BEAR (which see). *B* is operated by turning a screw, which causes the surfaces of an upper and a lower cam to roll in contact with each other, imparting a powerful pressure to the lower, which acts on the head of the punch.

Rail-straight'en-ing Ma-chine'. (*Railway Engineering.*) A machine for straightening crooked rails or iron bars. The illustration shows a portable device of this kind, consisting of a massive cast-iron table mounted on a truck, and having a presser-head operated by a lever which turns a screw working through a box in an upright standard. See also *F*, Plate XXV.

Fig. 4122.



Rail-Straightening Jack.

Rail'way. A way or road provided with rails, upon which the wheels of the carriages roll.

Roads with wooden rails (*tramways*) were first laid down by Mr. Beaumont at or in the vicinity of Newcastle, England, 1602. Between this and 1650 they began to become common in the Newcastle coal-fields, and were employed in transporting coal from the pits whence it was extracted to the *staiths* or discharging-places on the Tyne.

Their arrangement was thus described in 1676: —

"The manner of the carriage is by laying rails of timber from the colliery to the river, exactly straight and parallel; and bulky carts are made, with four rollers fitting those rails, whereby the carriage is so easy, that one horse will draw down four or five chaldrons [1 chaldron = 36 bushels] of coals." These "rails of timber" were laid upon transverse timbers or sleepers, and secured with pegs of wood, the sleepers being imbedded in the material of the roadway.

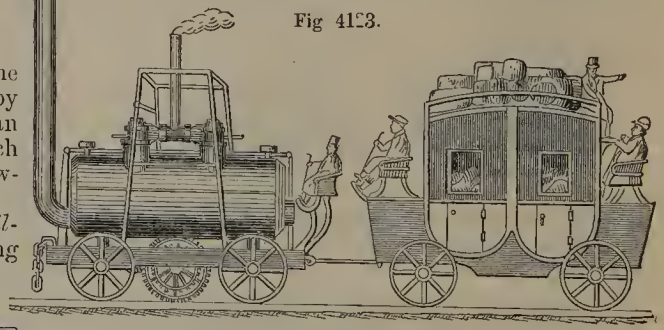
About 1716, the wooden ways were capped by thin plates of malleable iron. Cast-iron bars were substituted in 1767. In 1776, Carr took out a patent for cast-iron rails of L-shape to retain the wheels on the rails without flanges on the wheels. In 1800, stone props instead of timber for supporting the junctions of the rails were invented in Derbyshire by Mr. Outram. The name *tram*-road has been fancifully derived from Outram, but comes from *tram* (Prov. Eng., Sw., and Ger.), a beam; and the *trams* were the wagons which ran thereon. Birkenshaw, in 1820, invented and patented the rolled rail. See RAIL, page 1857.

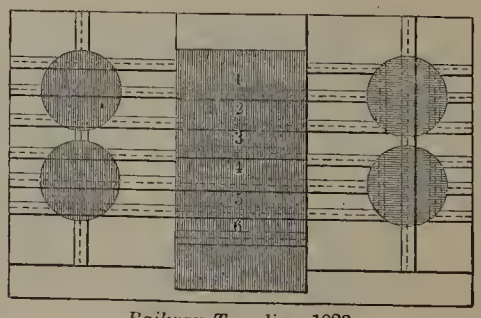
For the history of the LOCOMOTIVE, see under that head, to avoid repetition.

The following announcement was published in a London periodical, dated August 1, 1802: —

"The Surrey Iron Railway is now completed over the high-road through Wandsworth town On Wednesday, June 8, several carriages of all descriptions passed over the iron rails without meeting with the least obstacle. Among these, the Portsmouth

Fig 4123.





Railway Traveling, 1823.

wagon, drawn by eight horses and weighing from 8 to 10 tons, passed over the rails, and did not appear to make the slightest impression on them."

Fig. 4123 illustrates the locomotive, carriage, and track proposed in 1823 for a railway between London and Edinburgh. The locomotive was to have a toothed-wheel gearing with corresponding teeth on the rails, in order to insure sufficient traction. The rails were to be grooved, and carriages shifted sideways from one track to another by means of turntables and by series of rails 1 2 3 4 5 6 laid upon a movable platform. See LOCOMOTIVE.

The locomotive had previously been employed to a limited extent in the mining districts, and engines designed for running on common roads had been constructed as early as the beginning of the century; but it was first used with an encouraging degree of success for ordinary purposes on the Stockton and Darlington Railway, opened September 25, 1825.

Four years later, even a majority of experts were in favor of the use of stationary engines on the Liverpool and Manchester road, and it was not until after George Stephenson with his "Rocket" had practically demonstrated the capabilities of the locomotive, that the project of using the stationary engine was abandoned. This road was publicly opened September 15, 1830.

The first railway in the United States was one of two miles long from Milton to Quincy, in 1826; cars drawn by horses.

The Baltimore and Ohio Railway was commenced July 4, 1828, and was the first passenger railway in America, 15 miles being opened in 1830. The cars were drawn by horses till the next year, when a locomotive was put on the track, built by Davis of York, Pa. It had an upright boiler and cylinder.

The Mohawk and Hudson, 16 miles, from Albany to Schenectady, was the next line opened, during the same year, and the cars were drawn by horses till the delivery of the locomotive "De Witt Clinton," which was built at the West Point Foundry, N. Y. This was the second locomotive built in the United States; the first was made at the same shops for the South Carolina Railway.

The second locomotive on the Baltimore and Ohio Railway was built by James in 1832. It had a spark-arrester. It was the first to use four eccentrics. Its life terminated by explosion.

Baldwin, of Philadelphia, made a locomotive, "Old Ironsides," for the Philadelphia and Germantown Railway, in 1833.

The completion of the Baltimore and Ohio Railway was delayed for many years, largely on account of the difficulty of surmounting the elevation of 2,620 feet, the highest elevation above tide-water attained by that road at Altamont. When finished, this was considered a wonderful achievement; grades of 116 feet to the mile having been deemed insurmountable obstacles: now, however, they are considered but slight impediments, except so far as interfering with speed.

The Union Pacific crosses the summit ridge of the Rocky Mountains at an elevation of 8,460 feet; and the highest point on the railroad between Arequipa and Puno in Peru is 14,586 feet above the sea.

The length of the Panama Railway from the Atlantic to the Pacific Ocean is nearly 48 miles; the summit ridge is 287 feet above the mean tide of the Atlantic. The distance from New York to Hongkong via Cape Horn is more than 17,000 miles, but by this railway across the Isthmus it is less than 12,000, —a saving of 5,500 miles. This railway was opened in January, 1855. Starting from Aspinwall, on the Atlantic side, for Panama, on the Pacific, the traveler is soon in the midst of a scene of tropical beauty hardly to be surpassed in the world. Cocoa-palms and bread-fruit trees wave their branches on either side, and from the fastnesses of murky swamps richly colored aquatic plants rise in luxuriant wildness. The cries of gorgeously plumaged birds are heard on all sides, and now and then the discordant notes of monkeys, parrots, and other natives of the woods. On the low muddy banks of streams can be seen the huge forms of alligators sunning themselves and awaiting some unlucky object of prey. The towering trees are clasped in the vice-like embrace of plants of parasitic growth, and many tottering trunks attest the effect of close companionship. Along the sides of the road and upon the woody banks of the streams passed over are to be seen the thatched habitations of the mongrel specimens of humanity that live on the Isthmus. The rainy season commences in May and lasts until October, and it rains "hot water," according to the statement of the residents The wires of the Isthmus Telegraph Company run alongside the tracks. The dampness of the earth is guarded against by setting the telegraph-poles in concrete; the railroad-ties are made of lignum-vitæ, laid on a stone ballast. The telegraph-poles cost $5 each, and the railroad-ties $1.50 and $2 each. The railroad and rolling-stock have probably cost $12,000,000.

Stimpson's patents of 1831, 1835, describe the mode of turning curves in streets by raising the outer rail of the curve, so that the flanges of the off-wheels shall run above the rail, the tread of the inner wheels resting on the inner rail.

Among the *auxiliary devices to enable locomotives to ascend heavy grades* may be enumerated: —

A *center-rail*, grasped by horizontally rotating wheel or rollers, gripping the rail and driven by the power of the engine. See CENTER-RAIL.

A *rack-rail*, laid along the track and engaged by a cog-wheel upon and driven by the engine. See RACK-RAIL.

Converting each wheel of the train into a driver, by a temporary connection with the engine of the axles throughout the train.

James's English patent, 1825, has a horizontal shaft extended by couplings beneath the carriages the whole length of the train. This shaft was rotated by the engine when required, and connected by bevel-gearing with the axles of each car throughout the train.

The railway up the Rigi, in Switzerland, on the borders of Lake Lucerne, shown in Fig. 4124, is the work of three German engineers, Herren Riggenbach, Naeff, and Zschokke, the first-named gentleman having proposed the construction, an idea which was suggested to him by a visit to the Mount Washington Railroad, in this country.

The Rigi line starts from Vitznau, on the borders of the lake, and rises up the mountain-side to a station at Staffelhöhe, which is above the hotel and bath establishment, called Rigi Kaltbad, and well known to most travelers in Switzerland. The length of the line is 5,760 yards (about 3¼ miles), and the hight of the upper terminus above the lower is 3,937 feet, being an average ascending gradient of about 1 in 4½. After leaving Vitznau, the grades vary from 1 in 5 56 to 1 in 4. Among the instances of bold and difficult construction exhibited by this work is a bridge of three spans over a defile in the mountain, the track going into the side of a rock and through a tunnel. The bridge and tunnel together are 525 feet long, the grade being 1 in 4 and the direction a very sharp curve. The track is very solid and well built, and the locomotives have vertical boilers placed in the middle of their length. The boilers maintain their perpendicularity in ascending grades of 1 in 5¼.

The line was opened for public traffic on May 23, 1873.

Coleman's *device for ascending heavy grades*, English patent, July 30, 1845, consists of an endless screw beneath the locomotive and working into a line of rollers laid down midway between the rails. The screw is driven by bevel-gear fixed on the shaft of the driving-wheels and on the axis of the screw.

Parkins's *railroad* consists of a carriage traversing on rollers and drawn by a rope. It is said to have had a trial in the neighborhood of Paris, France. It is an absurd affair. The carriages have a bearing upon three or four sets of wheels at a time, and the rails are on the carriage, so to speak, a plated bar resting on the rails.

It is an inversion of the ordinary mode, wheels in pedestals at 6 feet apart all along the road and the carriage drawn thereon.

When, previous to the opening of the Liverpool and Manchester Railway, it was proposed to test the capabilities of the locomotive engine, it was made a requirement by the directors that a speed of 10 miles an hour should be attained. The Rocket on her trial-trip made 29 miles an hour at times, and rates of speed equaling or surpassing this soon became common on English passenger trains.

A train on the Chicago and Northwestern Railway recently ran 91 miles in 90 minutes. The quickest prior runs recorded in the United States are 14 miles in 11 minutes, by an engine and six cars, on the New York Central; 10 miles in 7¼ minutes, on the Pennsylvania Railway; 144 miles in 2 hours 49 minutes, on the Hudson River Railway; 84 miles in 90 minutes, from Indianapolis to Union City; 305 miles in 7 hours 42 minutes, from Albany to Niagara.

In ordinary running time, however, the English railways undoubtedly surpass all others. Between Paddington and Swin-

don, on the Great Western Railway of England, the distance is 77¾ miles, and both the up and down trains travel it in 87 minutes, including the starting and stopping, or at the rate of 53.62 miles per hour. At full pace, the speed is as nearly as possible a mile a minute.

The new express-train from Plymouth to London is probably the fastest train in the world in the part of its journey which lies over the Bristol and Exeter and Great Western Railways. Leaving Exeter at 10 30, it is timed to reach Paddington at 2.45; including a stoppage of five minutes at Bristol, and the inevitable and vexatious ten minutes at Swindon, the journey of 194 miles occupies 4¼ hours.

The speed of 70 miles an hour sometimes attained upon railways is equivalent to about 35 yards per second. At this rate

Fig. 4124.

Rigi Railway, Switzerland.

35 stakes one yard apart would be undistinguishable from each other; if painted red, they would appear as a continuous flash of red light. Two trains passing each other with this speed would have a relative velocity of 140 miles an hour, nearly equal to ¼ that of a cannon-ball; each train would pass the other in a single second; their united momentum would be equal to that of a number of cannon-balls aggregating $^1/_{16}$ their weight. The force of a collision under such circumstances may be imagined.

Supposing the driving-wheels of the locomotive in this case to be 7 feet, each will make 5 revolutions in a second; the piston traverses the cylinder 10 times in a second; as there are two cylinders there will be 20 puffs of steam in a second; the *coughs* produced by each single emission when the engine is moving at a comparatively low rate of speed being blended so as to produce an apparently continuous sound. See also

Atmospheric railway.
Elevated railway.
Pneumatic tube.
Portable railway.
Wire-way, etc.

Rail'way-brake. (*Railway Engineering.*) The old-fashioned hand-brake is still used on some lines of railway, but is gradually being superseded by power-brakes of various kinds.

A patent was granted in this country for a power-brake as far back as 1847, but the invention made slow progress, more patents having been granted for devices of this kind in the year 1872 than during the whole previous existence of the Patent Office.

Springs, electricity, steam, water, vacuum, and compressed air have been called into requisition in operating these brakes.

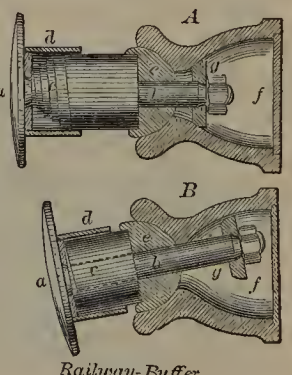
The total number of United States patents for power-brakes up to the close of 1872 numbered 59.

In England, from 1840 to 1866, there were patented 22 electric brakes; from 1835 to 1865, 20 hydrostatic brakes; from 1838 to 1866, 30 pneumatic brakes; from 1836 to 1866, 54 steam-brakes. Since 1869, seven companies for the manufacture of power-brakes have been organized in the United States, and more than one sixth of the 444 railroads in this country and Canada are now provided with them.

The principle, in all cases, consists in releasing, by means of devices at the hand of the engineer, a power stored up in some way, so as to permit it to push the brakes against the wheels of the cars; this involves a connection between the releasing mechanism, the source or sources of power, and the brake of each car in the train; these latter are, consequently, so arranged as to be readily coupled and uncoupled from one another. See BRAKE; AIR-BRAKE; CAR-BRAKE; STEAM-BRAKE; PNEUMATIC BRAKE.

Rail'way-buf'fer. A fender on the end of a car to receive the impact of another car and deaden the shock. In Fig. 4125, the head *a* is fixed on a rod *b* passing through the spring *c* in the collar *d*, and also through the semicircular block *e*, which fits a corresponding cavity in the box *f* attached to the end of a car. The rod has a collar *g* on its inner end, preventing its withdrawal from the box, but allowing free movement within it, so that while direct pressure on the buffer-head forces it directly backward, angular pressure, such as may be ex-

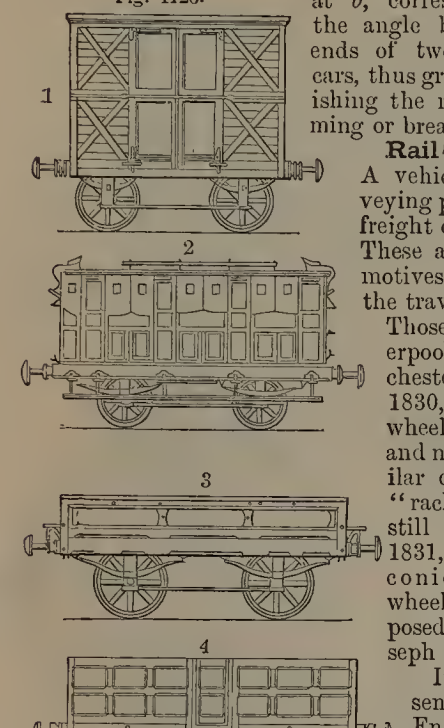
Fig. 4125.



Railway-Buffer.

erted in turning a curve, causes it to assume a position similar to that shown at *b*, corresponding to the angle between the ends of two adjoining cars, thus greatly diminishing the risk of jamming or breakage.

Fig. 4126.



English Railway-Carriages.

Rail'way-car. A vehicle for conveying passengers or freight on railways. These and the locomotives constitute the traveling plant.

Those on the Liverpool and Manchester Railway, 1830, had four wheels, no springs, and no roof; similar cars, termed "rack-cars," are still in use. In 1831, springs and conical tread-wheels were proposed by Mr. Joseph Knight.

In 1839, passenger-cars in England comprised first-class, which were of superior finish and provided with cushioned seats; second-class, of plain finish, without cushions or ornaments; third-class, little more than boxes on wheels, having seats, but frequently without a roof.

In addition, there were "mixed" carriages, divided into three compartments, the center one of which was for first-class and those at each end for second-class passengers.

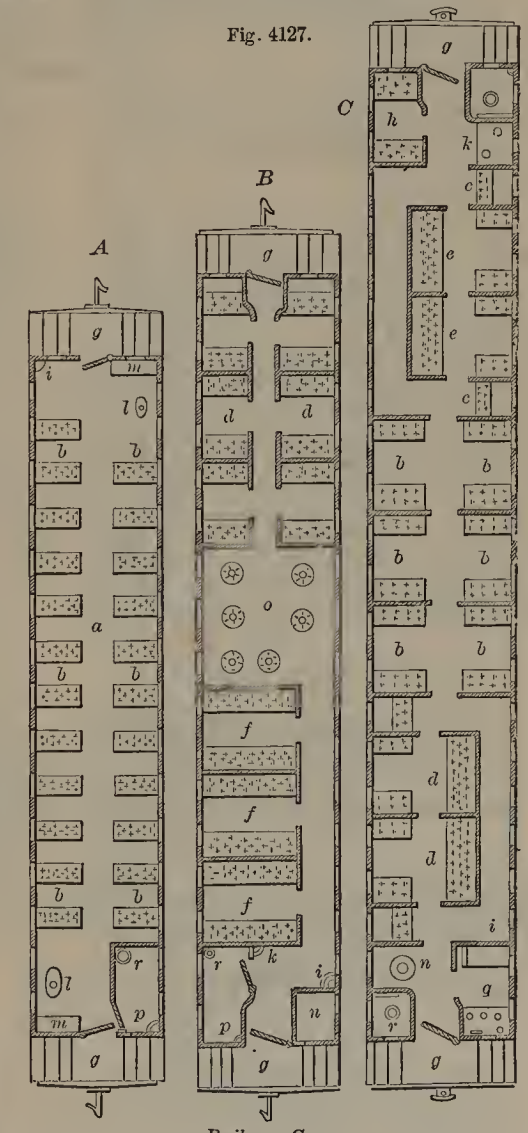
Hanson introduced in England, 1847, an iron car divided into compartments, each of which contained a single seat so arranged that the occupant would face the direction in which the train was moving. A double footboard lined with sheepskins, between which the feet could be thrust to keep them warm, and a leather-covered head-board or cushion lined with sponge, to deaden shocks, formed appendages to each seat. The same inventor also introduced a similarly constructed freight-car with a sliding roof. In the same year, a wrought-iron car-wheel made in sections, united by tongues and grooves, and expanded to fit the tire, which was in one piece, by means of a conical ring in the hub, made its appearance in England.

The rolling-stock of English railways differs from that in the United States in many respects. The distinction of three classes is not usual with us, and, except on emigrant lines, a second class is not very common in the United States. The doors of British passenger-cars open at the sides. The interiors are divided into compartments. The furnishing of all but the first-class is mean, and intended to drive respectable people into the most costly carriages. The third-class is like a cattle-car, except that it has boards to sit on instead of boards overhead for protection. It also differs from a coal-wagon in having seat-boards, and in the fact that the passengers are expected to get out of themselves as there is no provision for dumping them. The traveling is (or was) safe, the police arrangements excellent, the baggage arrangements execrable.

The appearance of the cars or carriages will be better understood from the illustrations in Fig. 4126.

1, luggage-van.
2, second-class carriage.
3, carriage-truck.
4, third-class open passenger-carriage.
5, express or mail carriage.
6, coal-wagon.
7, first-class carriage.
8, goods-wagon.
9, timber-carriage.

Fig. 4127.



Railway-Cars.

A, Passenger-Car. B, Saloon-Car. C, Hotel-Car

American passenger-cars are constructed on a very different plan from those of Europe, where, with the exception of Russia, those of England served as a model.

The long car, consisting of a single apartment capable of containing many passengers, the bell-cord, the swinging truck, the stove, drawing-room, sleeping, and hotel cars, as well as the baggage-check system, are all of American origin.

The general arrangement of ordinary passenger-cars differs but little on American roads. All have a central passage with a row of double seats on each side, and conveniences for passengers at one end of the car.

The arrangement of what are known as saloon, palace, hotel, restaurant, and sleeping cars differs somewhat from these.

Fig. 4127, *A* represents an ordinary passenger-car; *B* a saloon-car, with close compartments; and *C* a hotel-car.
a, central passageway.
b b, double seats, which may be turned face to face, or back to back.
c c, seats for the waiters or employés.
d d, close compartments, with seats for four persons.
e e, compartments, with seats for five persons
f f, compartments with seats for six persons
g, exterior platforms.
h, smoking compartment, four seats.
i, water-cooler.
k, wash-staud.
l l, stoves.
m m, wood and coal boxes.
n, special heating apparatus.
o, saloon, with five pivoted arm-chairs.
p, urinals.
q, kitchen.
r, water-closet.

Plate XLV. shows a modern Russian saloon-car, convertible into a sleeping-car. It presents an example of the best which has been done in Europe in the way of adapting railway-cars to the comfort and convenience of passengers. The car shown is about 40 feet long and 10 wide, outside measurement, to run on a road of 5-feet gage. The large compartment has seats for 12 passengers, the two smaller for 6 each. The windows are few and small, owing to the rigor of the Russian climate, which renders the heating of a car with many openings a matter of difficulty. The "platform" at each end of the car is inclosed, has side doors, and serves as a corridor.

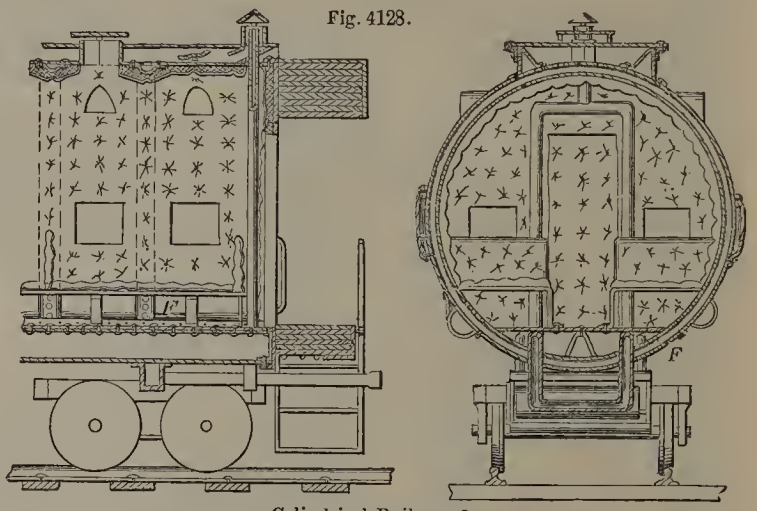
An upright boiler in the small compartment next the wash-room serves to heat several cars by steam-pipes under the floor. The water of condensation is returned in the same way to the boiler.

The car-body rests on three pairs of wheels, without trucks.

Taylor (English patent, May 11, 1841) proposed to make railway-cars of papier-maché.

Paper wheels have also been used for railway-cars. The paper is cut into disks the diameter of the wheel less the thickness of the tire, subjected to a pressure of one and a half tons to the square inch, and then secured by iron flanges held by bolts passing through them and the paper. The wheels then receive a steel or iron flagged tire. The advantages claimed for paper are, that it is noiseless, does not spring or shrink with the weather, affords a stay to the tire and a lateral support in turning curves, adapts itself to any trifling inequality of the inner surface of the surrounding tire, and is stronger than any other material of the same weight of which a wheel may be made.

Fig. 4128.



Cylindrical Railway-Car.

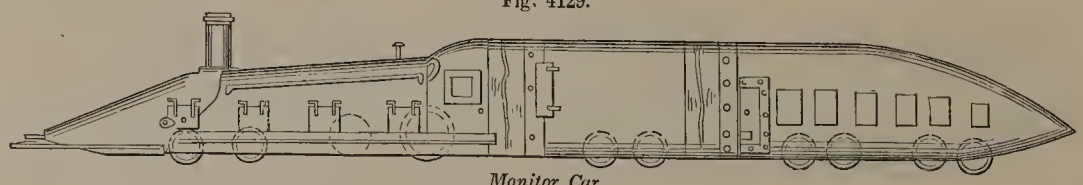
Robbins's car (Fig. 4128) is cylindrical and made of plate-iron. Hollow ribs *F* surround the interior of the body to stiffen it, and also to receive and discharge fresh air through different apertures; farther stiffening is likewise effected by semi-cylinders of sheet-iron and the wrought-iron floor. Attached to the roof-plate to support it are angle-irons, while an elastic platform serves to break the violence of collisions.

It has been proposed to construct cars of a tapering or spindle shape, so as to present less resistance to the air. The game is not worth the candle.

The Master Car-Builders' Association made public the following statistics relative to the number of steam-cars on all roads of four feet eight inches and wider gages in the United States and Canada at the close of the fiscal year ending with 1871, namely: —

Whole number of 8-wheel cars	193,767
Whole number of 4-wheel cars	58,355
Total	252,122
Whole number of cars reported for 3-foot and 3½-foot gage roads	212

Fig. 4129.

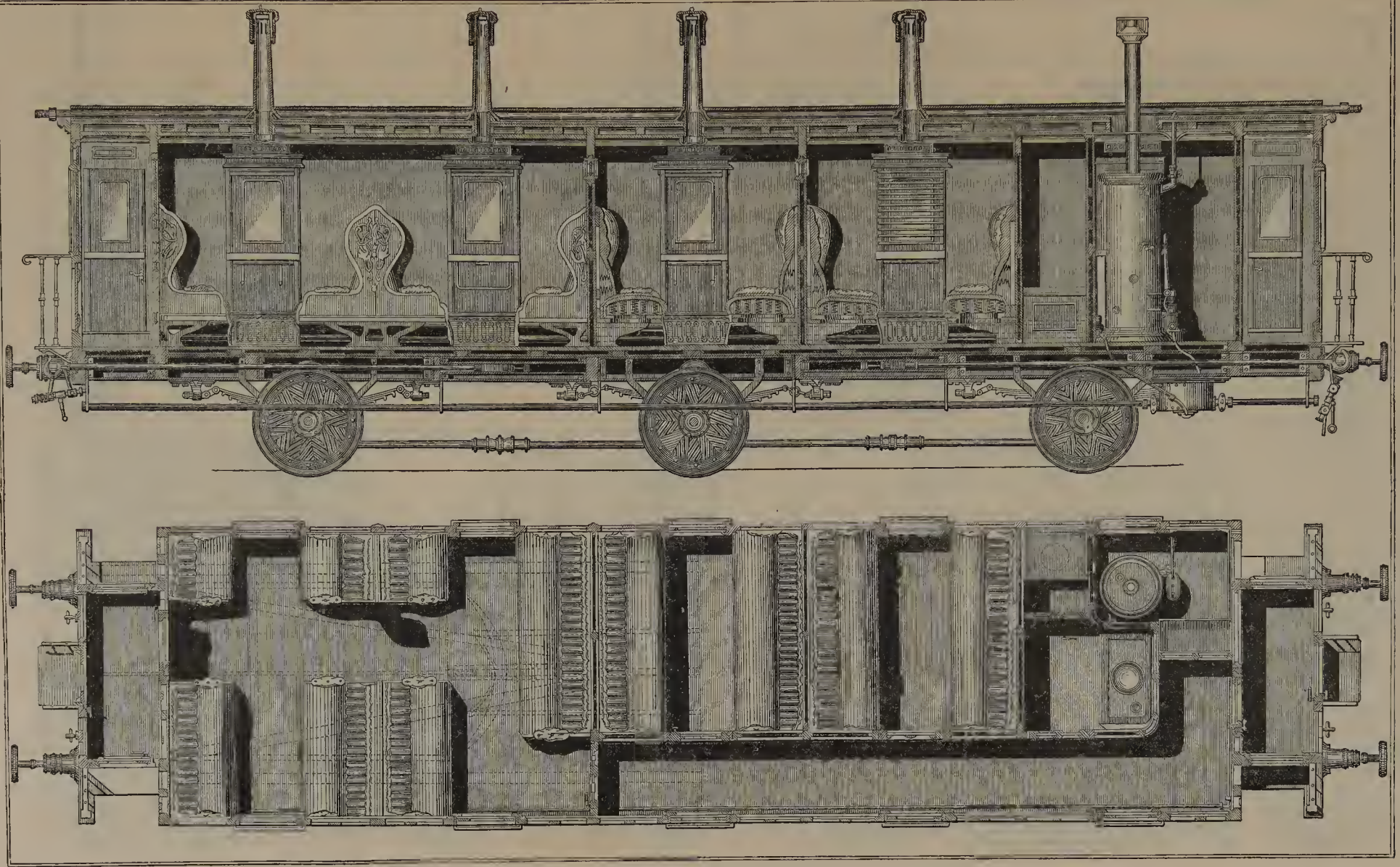


Monitor Car.

There are 103 car-manufacturing establishments in the United States and Canada, which built during the year ending May 31, 1873, the following cars: —

Palace, sleeping, and hotel cars	134
Passenger-cars, all classes	579
Smoking-cars	18
Baggage and smoking cars	15
Baggage and express cars	18
Baggage and mail cars	33
Baggage-cars	63
United States postal cars	3
Total number of cars for passenger trains	863

Paymaster	6	Grain combination	750
Caboose	78	Box or house	11,931
Fruit	734	Platform	5,694
Refrigerator	8	Gondola	6,733



FIRST-CLASS RAILWAY CARRIAGE, MOSCOW AND KOORSK RAILWAY, RUSSIA.

(Built at the Company's Works, Moscow.)

PLATE XLV.

See page 1864.

Double-bot'm gondola.	125	Construction	162
Double deck	80	Steam shovels	52
Hay (box)	75	Derrick	8
Stock	2,415	Hand	149
Ore and coal, 8-wheel..	3,126		
Ore and coal, 4-wheel..	3,226	Total	371
Oil-tank (60 barrels)...	250		
Oil-tank (64 barrels)...	300		
Total	35,531		

Making whole number of cars built by car-manufacturing companies during year ending May 31, 1873..... 36,765

Cars of the various classes as follows were also built by railway companies during the year ending May 31, 1873 : —

Day and night palace..	69	Milk	152
Passenger	281	Refrigerator	18
Smoking	14	Hay	132
Baggage and smoking.	43	Combination	407
Baggage and express...	84	Oil and coal, 8-wheel...	3,119
Baggage and mail	27	Oil and coal, 4-wheel...	3,201
Baggage	101	Stock	1,452
Postal	19	Oil-tank (64 barrels)...	105
Paymaster	6	Construction	385
Caboose	831	Hand	828
Box or house	5,673	Derrick	14
Platform	2,643	Snow-plows	19
Gondola	2,543	Service or pole	50
Grain	129		

Whole number of cars built by railway companies... 22,345

The following cars were built for narrow-gage roads, namely, three feet to three and a half gage, during the same time : —

Passenger	16	Platform	37
Smoking	2	Oil-tank	48
Baggage and smoking....	1	Hand	3
Baggage	5		
Box and house	17	Total	129

Cars constructed by railway companies..... 40
Add 85 cars for six months intervening between close of fiscal year 1871 and June 1, 1872..... 85
Also number officially reported in 1871..... 212

Total for narrow-gage roads..... 466

Add to this the number of cars constructed by the car-manufacturing companies, and we have for the number of cars which were added to our rolling-stock during the year ending May 31, 1873, 59,110. Allowing six months for the time between the close of the fiscal year 1871 and the 1st of June, 1872, we will add one half the number of cars constructed during the year 1872 to the number officially reported in 1871, and we have for number of cars on the 1st of June, 1872, 281,667. Add to this the number manufactured during 1873, and it gives us for the total number of cars, 340,787.

The increase here stated is probably under the mark, as a few companies did not report. The figures indicate that the increase in the number of cars for the year 1873 was about twenty-five per cent.

For other cars, both passenger and freight, designed for particular purposes, and known by different specific names, see

Box-car.	Postal-car.
Cattle-car.	Sleeping-car.
Coal-car.	Street-car.
Freight-car.	Tank-car.
Hand-car.	Tool-car.
Petroleum-car.	Wrecking-car.

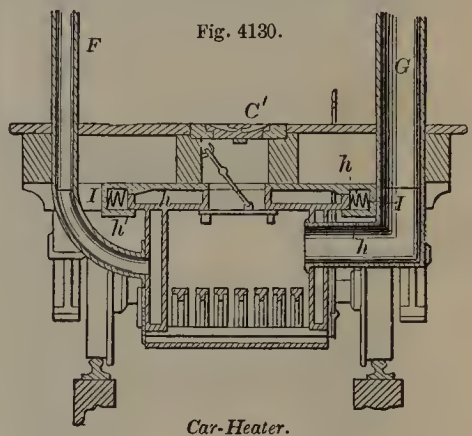
See also list under RAILWAY ENGINEERING AND PLANT.

Rail'way-car Heat'er. A device intended to obviate the dangers attending the use of the common stove in railway-cars.

Among other propositions for this purpose is one designed to utilize the heat of the boiler and fire-box of a railroad locomotive to warm a train of cars in cold weather, and to ventilate the cars with pure air free from dust or cinders in summer. The front of the locomotive is provided with a funnel-shaped mouth, from which a pipe leads down under the boiler and in close contact therewith. At the forward end of the fire-box it divides into two branches, one passing along each side and through the tender, at the rear of which they again unite. Each car is furnished with similar pipes passing along under the seats, and fitted with registers that may be opened and closed at will. The union between the pipes of the different cars is by means of a bell-mouth containing a packing for the end of the pipe, but sufficiently yielding to allow of lateral motion in rounding curves, etc. The front end of the pipe has a hood inside the funnel mouth, to prevent rain or snow from entering.

Beal's heater is supported beneath the car by flanges *h h* resting in cavities having spiral springs *I*, which ease the jar caused by the motion of the train. In case of collision or running off the track, the concussion releases the flanges from their supports and

Fig. 4130.



Car-Heater.

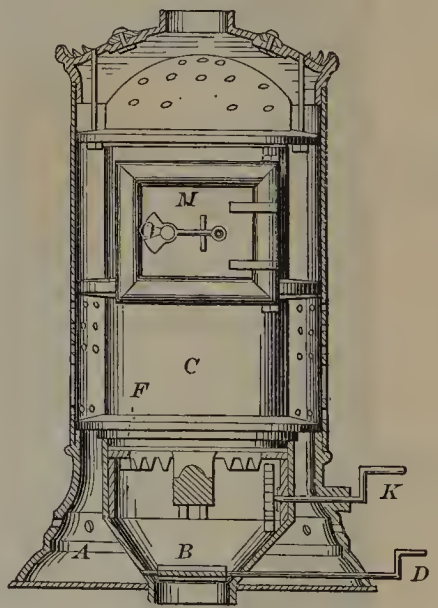
detaches the apparatus from the car. *F* is the air-supply pipe, and *G* the chimney ; *C'*, a covered aperture in the floor, through which fuel is introduced. See also CAR-HEATER.

Rail'way-car Stove. The special requirements in a stove for use on railway-cars are that it shall not be readily upset, and that in case of an accident of this kind fire shall not be communicated to the wood-work. The absence of these requirements has been the cause of numerous frightful losses of life, some of which will, no doubt, be vividly remembered by our readers.

A number of arrangements have been devised to obviate or lessen the liability to this danger.

In Fig. 4131, the cylinder *C* rests upon a solid base *A*. The door *M* is depressed below the general surface, and has a sunken spring-latch *Q*, so that it cannot be accidentally opened. The revolving grate

Fig. 4131.

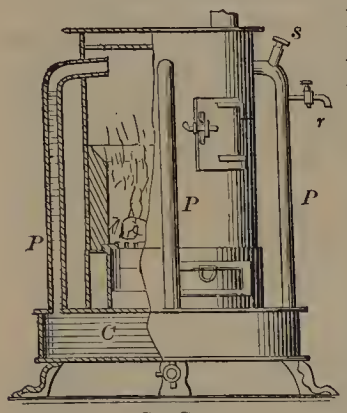


Railway-Car Stove.

F has teeth meshing with a pinion turned by the crank *K*, and the ash-pit *B* is provided with a slide-valve and rod *D* for removing ashes and regulating draft.

Wheelock's (Fig. 4132) is supported on a water-

Fig. 4132.



Car-Stove.

chamber *C* having pipes *P P P* around the stove-cylinder, with which their upper ends communicate. These and the chamber *C* are filled with water through the opening *s* to the hight of the overflow-cock *r*. In case of being overturned, the water flows into the cylinder and extinguishes the fire.

Rail'way-chair. (*Railway Engineering.*) *a*. A block or plate in which the foot of a rail is secured, so as to form a shoe, giving it a base of support upon the sleeper and securing it thereto.

It is especially needed with T and double-headed rails, which cannot be effectually spiked to the sleepers. The *foot-rail* and bridge-rail have a broad flange on each side and are readily secured by spikes.

Broad chairs at the joints of rails are sometimes made to act as *fish-plates*, to secure exact continuity to the abutting rails and support their ends. The long lips of the chair embrace the webs of each rail. They are or were made 15 × 18, 16 × 13, 14 × 11, the length in the direction of the rail.

Rails are bolted or keyed to the chairs, many devices of each kind having been introduced in this country and in Europe.

Mr. Jessop of England first invented the rail-chair in 1789, and used it at Loughborough, in Leicestershire. The rail used by Mr. Jessop was a cast-iron rail, laid edgeways. The chair was cast-iron, and was slotted to receive the ends of the rails, which had a bearing therein It was used in connection with a cast-iron, fish-bellied edge-rail which he introduced in the same year. He had previously pinned the rails direct to the sleepers.

A chair for railway rails was patented by Loch and Stephenson in 1816. The rail to which it was first adapted was a fish-bellied rail, whose ends were halved together and tied by a transverse bolt, which also passed through the flanges of the cast-iron chair. The invention arose from the necessity of something to hold the reduced ends firmly together, so that they should spring neither laterally nor vertically.

Brunton and Shield's *railway-chair* was also of cast-iron, and was secured by spikes to the sleeper. A single vertical flange gave a point of attachment for the web of the rail, which was bolted thereto.

Some other examples of the earlier forms of chairs may be seen by referring to Rail

The chair *a* adopted by the London and Birmingham Railway was one of cast-iron, having a slot which admitted the rail laterally, a chock being afterward slipped in laterally between the outer abutment of the chair and the web of the rail, the chock itself being secured by a wrought-iron key, driven vertically.

Robert Stevenson's patent railway-chair *b* had lugs, through which oblique keys were driven to hold the rail in the chair. In the double chair, at the joints, two keys were inserted. At intermediate points a single key sufficed.

Scrivenor's *wrought-iron railway-chairs* were made by rolling and pressing in 1832. The bar is run between rollers, on each passage receiving a form more nearly approximating that of the chair. The bar is then cut into sections by shears. The chair being heated red-hot, a mandrel of the size and shape of the rail is driven into the place it is to occupy, and the chair is then passed between a pair of rolls, which give it the final shape. *c* illustrates a wrought-iron chair used on some American railways.

In *d* the two-part rails have lap-joints, and are held together in place on the track between the horns of the chair.

The rails in *e* rest in grooves in the parts of the chair which are held together by a bolt.

f is a rail and two-part chair, the latter rising high enough for a bolt which passes through the web of the rail, and as high as the rail on the outside.

g is a chair in one part

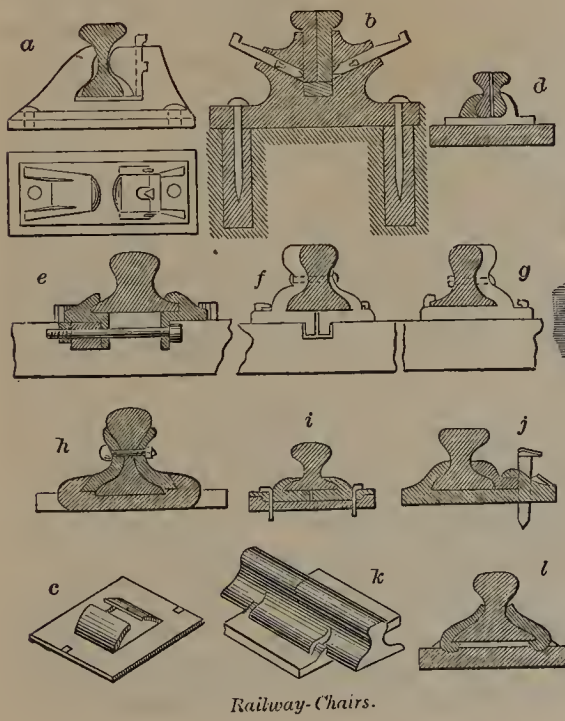
h has a base-piece and a pair of cheeks, with a bolt through the web.

i has two cheek-pieces, base-piece, and spikes.

j has a base-piece with a prong, a cheek-piece, and a spike.

k l represent a chair having cheeks which grasp the rail by the pressure of the train.

Fig. 4133.



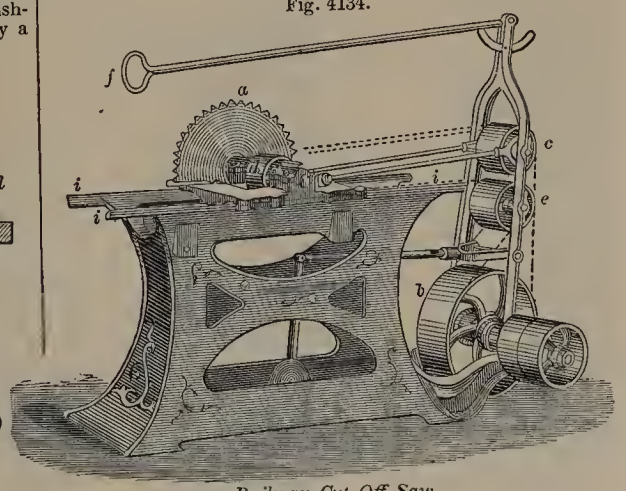
Railway-Chairs.

b. A chair adapted for a railway-car. See Car-seat.

Rail'way Cut-off Saw. A buzz (circular) saw, which may be fed back and forth to its work.

In Fig. 4134 the saw *a* is driven by a belt from pulley *b*, which passes over idler *c*, around saw-pulley *d*, then over a second idle-wheel *e*, and back to

Fig. 4134.



Railway Cut-Off Saw.

b. By this arrangement of pulleys the belt is maintained at an even tension, while the saw-carriage slides back and forth on tracks *i i*. A handle *f* controls the movement of the saw-carriage.

Rail'way En'gi-neer'ing and Plant.

Adhesive car.
Aërial car.
Aërial railway.
Arcade railway.
Archimedean railway.
Atmospheric railway.
Axle.
Axle-box.
Axle-guard.
Ballast.
Ballast car or wagon.
Bed.
Bogie-frame.
Bottoming.

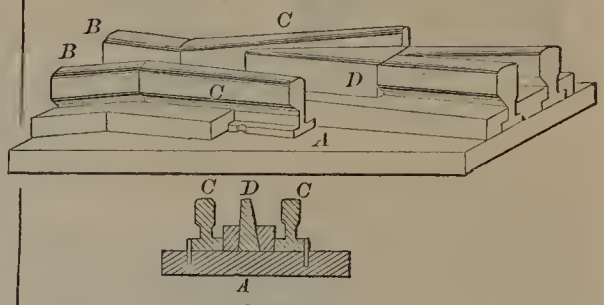
Box-car.
Brake. Railway-car
Broad gage.
Buffer.
Bumper.
Bumping-post.
Car. Railway
Car-axle.
Car-brake.
Car-cab.
Car-couch.
Car-coupling.
Car-heater.
Car-platform.
Car-register.
Car-replacer.
Car roof.
Car-seat.
Car-spring.
Car-stake.
Car-starter.
Car-truck.
Car-truck frame.
Car-truss.
Car-ventilator.
Car-wheel.
Car-window.
Car-window fastening.
Cattle-guard.
Chair. Railway
Claw-bar.
Climber.
Coal-car.
Compound axle.
Construction-way.
Cow.
Cow-catcher.
Crank-axle.
Cross-sill.
Cross-frog.
Crossing. Railway
Cross-tie.
Derailment.
Divided axle.
Drag-bar.
Drag-link.
Draw-bar.
Draw-head.
Draw-link.
Draw-spring.
Dummy-car.
Dumping-car.
Electric railway-signal.
Elevated railway.
Fender-stop.
Fish-bar.
Fish-plate.
Fog-signal.
Freight-car.
Frog. Railway
Gage. Concussion
Gage. Railway
Goods-wagon.
Gradient.
Gradient-post.
Gravel-car.
Grease-box.
Guard-rail.
Hand-car.
Head-rest.
Horn-plate.
Horse-railway.
Hotel-car.
Housing.
Hurries.
Inclined plane.
Jaw-wedge.
Joint-chair.
Joint-fastening.
Joint. Railway-rail
Locomotive-car.
Luggage-van.
Marine railway.
Narrow gage.
Palace-car.
Passing-place.
Pedestal.
Permanent way.
Petroleum-car.
Plant.
Plate-railway.
Platform-car.
Pneumatic railway.
Point.
Pointer.
Portable railway.
Postal car.
Provision-car.
Pullman-car.
Rail.
Rail-clamp.
Railway.
Railway-car.
Railway-car heater.
Railway-car stove.
Railway-chair.
Railway-clamp.
Railway-crane.
Railway-gage.
Railway-gate.
Railway-jack.
Railway-joint.
Railway-plow.
Railway-rail
Railway-signal.
Railway-slide.
Railway-sweeper.
Railway-switch.
Refrigerating car.
Restaurant-car.
Revolving-car.
Road-bed.
Rolling-stock.
Rope railway.
Safety-car.
Safety-guard.
Saloon-car.
Sand-box.
Shunt.
Side-cutting.
Side-space.
Siding.
Signal. Railway
Sleeper.
Sleeping-car.
Slope.
Snow-plow.
Spark-arrester.
Spike.
Splice-piece.
Spoil.
Staith.
Station-indicator.
Steam-brake.
Stopper.
Street-car.
Street-railway.
Stringer.
Subterranean railway.
Switch.
Switch-lantern.
Switch-signal.
Switch-stand.
Tank-car.
Tank-locomotive.
Tender.
Tie.
Tongue.
Tool-car.
Track.
Track-clearer.
Track-layer.
Track-laying railway.
Track-raiser.
Traction-engine.
Trailer.
Tram.
Tramway.
Tram-wheel.
Traverser.
Traverse-table.
Traversing-jack.
Truck.
Trunk.
Turn-out.
Turn-table.
Underground-railway.
Uno-rail.
Water-crane.
Water-elevator for railways.
Wire-way.
Wooden railway.
Wrecking-car.

Rail'way-frog. (*Railway Engineering.*) A device by which cars are guided from one line of rails on to another, when they form angles with each other.

A single V-shaped piece, or two such pieces, point to point, are fixed to or form part of a plate, their upper surfaces being in line with the rails of each track, so as to serve as a support and guide for the wheels as they pass from one track to the other. A guard-rail is also arranged on one or both sides of the angular piece or *point*.

In Fig. 4135, the frog-plate *A*, track-sections, guard-rails *C*, and frog-point *D* are separate from

Fig. 4135.



Railway-Frog.

one another, and so constructed that the rail sections, guard-rails, and frog-point can be inserted in or attached to and detached from the frog-plate.

Rail'way-gage. The distance apart of the two lines of a railway, forming a track, measured between the inner edges of the tread-flanges.

The *gage* of a *carriage* is the distance between the wheels. It is ordinarily called the track. One of these generally prevails in a section of country, to the exclusion of the other. The broad track is 5 feet or more from center to center of tire. The narrow track is $4\frac{1}{2}$ feet or less between the same points.

1. The wooden tramways of the collieries, before the invention of the iron rail, had a gage of 4 feet. The roadway was scantling, 5×7, pegged down to oak sleepers, 4×8, 6 feet long, and laid $2\frac{1}{2}$ feet apart. The track for the horses was filled in with ashes above the sleepers.

The Stockton and Darlington Railway, one of the first on which the locomotive was used (1825), has a gage of 4 feet $8\frac{1}{2}$ inches. This was adopted on almost all the British railways, and was called the *narrow* gage, in contradistinction to that of the Great Western Railway of England, which had a *broad* gage of 7 feet.

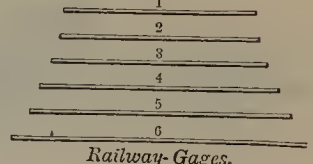
The usual gage in England and the United States, and now compulsory in England, Belgium, France, Italy, and Germany, is 4 feet $8\frac{1}{2}$ inches, the gage common in the tramways of the collieries of England before the invention of the locomotive. Ireland retains its own gage. The 4 foot 8 inch gage was very sensibly retained by Stephenson; but Brunel, who could not condescend to copy, adopted 7 feet as the gage of the Great Western Railway of England. After this very expensive railway had been in operation for more than a score of years, the gage was changed to conform to the customary English practice. The same events have happened or will happen with the so-called broad gage — 6 feet — of this country; Erie, Atlantic and Great Western, Ohio and Mississippi, and Grand Trunk railways.

Brunel was "regardless of expense." His track of 7 feet between the rails involved other increased expenditures, such as wider tracks, bridges, tunnels, embankments, viaducts, heavier sleepers, rails, and chairs; a heavier expenditure in rolling-stock both as to first cost and wear and tear. He, however, had pitted himself against Stephenson, and the shareholders had to suffer for thirty years. The railway has now been brought to the standard gage, and the owners look for better times.

In 1846, the English government determined to make the 4 foot $8\frac{1}{2}$ inch gage the standard for all future works.

Brunel's objects in increasing the gage from 4 feet 8 inches to 7, an addition of 2 feet $3\frac{1}{2}$ inches were to allow the employment of larger and more powerful engines with larger driving-wheels; to increase the stability and steadiness by placing the body of the carriage within the wheels,

Fig. 4136.



Railway-Gages.

lowering the center of gravity; to increase the carrying capacity of the cars.

The foregoing diagram affords a means of comparing the railroad gages.

1, Scotch, narrow	4	feet	6 inches.
2, common English and American	4	"	8½ "
3, Eastern counties and Blackwall, England, as originally constructed	5	"	
4, Scotch, broad, Canadian Grand Trunk, East Indian	5	"	6 "
5, Irish	6	"	2 "
6, Great Western, as originally constructed (English broad)	7	"	

Forty-two inches is to be the gage of the Nile Railway from Wady Halfa to Shendy, skirting between the Nubian and Libyan deserts, a distance of 560 miles.

Within the past few years a number of tracks have been laid of narrower gage even than this, varying from 3 feet even down to 1 foot 11½ inches, as the Festiniog Railway in Wales. See Fig. 3296, page 1512.

Mr. Fairlie, in a paper read before the British Association, asserts that the proportion of non-paying to paying weight which an engine has to draw on the English roads is as 29 to 1, and in freight-trains 7 to 1, while on the Festiniog road cars weighing 12 cwt. are made to carry 3½ tons at a speed of 12 miles an hour. Also, that a speed of 30 miles an hour may be attained on a road of 2 foot 6 inch gage, and of 40 miles on one of 3 feet. Higher speeds are not required in new and thinly settled countries.

While gages of 4 feet 8½ inches and upward are undoubtedly advantageous where great speed is necessary and large amounts of freight are to be carried, the advocates of the narrow gage appear to have the best of the argument, so far as its economy is concerned in cases where the traffic and travel do not justify the outlay of such a large amount as the broad gage and its rolling-stock demands. See NARROW GAGE.

In the English parliamentary commission for taking evidence as to the expediency of making the gage uniform for the Kingdom, the following expedients were cited as means of adapting trains or carriages to traverse variously gaged tracks: —

Telescopic axles.

Mounting carriages on trucks of different gages. That is, running car-wheels and all on to a sub-truck having the gage required.

Shifting the body from one truck to another.

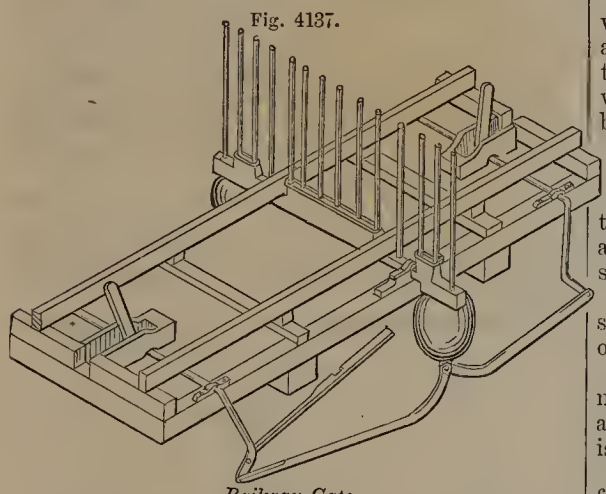
Carrying the freight in boxes which are shifted on to platform-cars having the gage required.

Combining the gages on one line.

2. A bar with shoulders, indicating the distance between the rails, and by which they are laid.

Rail'way-gate. A gate at a railway-crossing, on the level of a common road or street. Such are usually tended by guards or watchmen, but attempts

Fig. 4137.



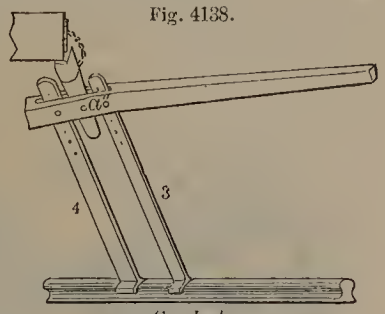
Railway-Gate.

have been made to operate them by means of the passing trains. In Fig. 4137 the gate is laid down by the pressure of the passing train upon the upwardly projecting arm of the rock-shafts to which the gate is connected.

Rail'way-jack. (*Railway Engineering.*) A lifting device for pulling up rails, raising cars, and other like purposes.

Fig. 4138 has two standards 3, 4, having holes near their upper ends, so that the lever *a* may be pivoted at various hights; the shoes resting on the rail.

Fig. 4138.

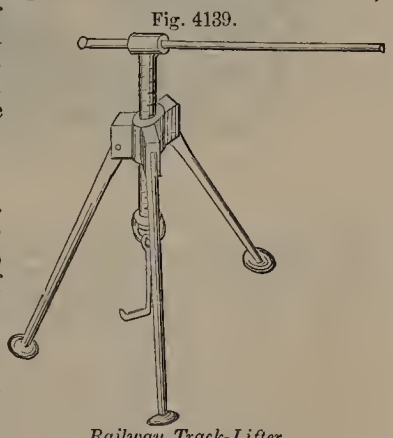


Car-Jack.

The lifting-head is bolted in a slot in the lever between the standards which pass through the slot, and is placed beneath an angle of the object to be lifted.

Fig. 4139 is a tripod-stand, with a lever and screw, from whose lower part is suspended a hook, which is inserted beneath a rail for the purpose of tearing it from the tie.

Fig. 4139.



Railway Track-Lifter.

Rail'way-joint. (*Railway Engineering.*) The junction of two rails in the same line; it is usually a butt-joint, but in some cases the rails are halved together.

Rail'way-plow. (*Railway Engineering.*) See SNOW-PLOW.

Rail'way Print'ing-ma-chine'. (*Printing.*) One in which the bed is carried by a truck upon a railway, being usually driven by a crank motion.

In Fig. 4140, *d* is the type-bed which rests upon the truck and reciprocates beneath the cylinder upon the railway-track *b*.

The paper is fed to the under side of the cylinder *c*, which, after an impression is given, remains stationary while the bed *d* returns, and the fingers close on the next sheet before it starts again. The cylinder-wheel gears directly into a rack on the side of the bed, and register may be obtained without a pointing apparatus. The impression-cylinder is not shifted to suit forms of different sizes, but the forward edge of the type is always placed on the same line on the bed. The feed-board *e* is hinged to turn up and allow access to the form. Tapes *i i* carry the printed sheet to the fly *f*.

Rail'way-saw. A sawing-machine in which the saw-mandrel is mounted on a carriage which slides on ways. See RAILWAY CUT-OFF SAW.

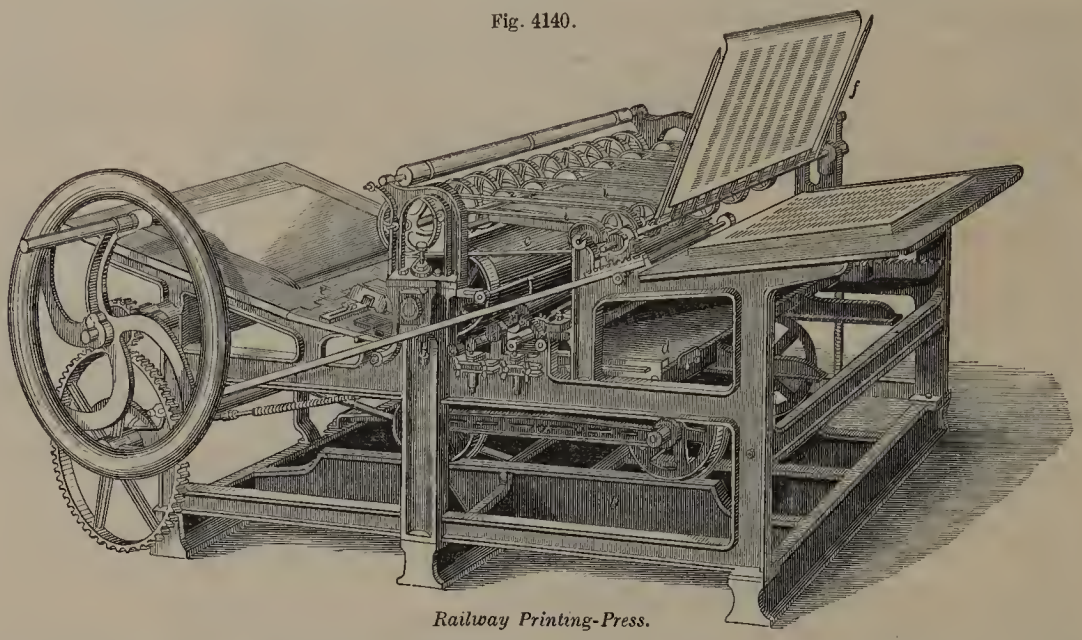
Rail'way-sig'nal. (*Railway Engineering.*) Signals are used on railroads to indicate safety, danger, approach to a station, that a switch is in place or is displaced, and for various other purposes.

Both audible and visible signals are employed, the former being produced by the engineer with the steam-whistle, by bells or by torpedoes.

The following code, though limited in expression, is universally understood, at least on American roads: —

One whistle of the locomotive means "down brakes"; two whistles, "off brakes"; three whistles, "back up"; continued whistles, "danger"; a continued succession of short whistles is the cattle alarm. The conductor's signal, given by a sweeping parting of the hands on a level with the eyes, means "go ahead." A downward motion of the hand, "stop." A beckoning motion, "back." A lantern raised and lowered vertically,

Fig. 4140.



Railway Printing-Press.

"start"; swung at right angles or across the track, "stop"; swung in a circle, "back." A red flag waved on the track, "danger"; hoisted at a station, "stop"; stuck up by the roadside, "danger on the track ahead"; carried unfurled on an engine, "another engine is on its way."

The New York and Erie was the first road which constructed a line of telegraph to be used exclusively for transmitting messages in relation to the business of the road, and upon it was introduced the system now in general use of controlling the movement of the trains by telegraph.

In this system the whole of the trains are under the control of a superintendent at headquarters, who is notified by the operator at his station of the time when each train arrives at his station. Having the time-table of the road before him, he is enabled to give directions to the conductor of each train to go ahead, stop, or turn off at a siding ahead, as may insure the track being clear for the train which has the right of the road and prevent danger of collision.

Under another system employed on some double-track roads, each operator is required to telegraph to his neighbor on the passage of a train, who, on its approach, if the track be clear ahead, displays a safety-signal; or, if not, a danger-signal, when the train is stopped. This arrangement provides against danger of collision by trains proceeding in the same direction; but the number of operators required and the expense of maintenance have led to the trial of automatic electro-magnetic devices by which these station-signals may be operated.

In 1867, Mr. Thomas S. Hall patented an electric signal, so arranged that the displacement of a rail at a switch or draw-bridge would exhibit a signal at the distance of half a mile or more in each direction, at the same time causing a bell to ring until the source of disturbance was removed. This was, however, effected by closing the circuit, so that in case of accident to the apparatus itself, the signal would not be made, nor would its failure to operate be detected without an inspection.

Mr. Wm. Robinson, in 1870, invented a continuous circuit arrangement in which the danger-signal was kept constantly exhibited, except when the circuit was broken by the wheels of an approaching train striking a lever at the side of the track. If a rail were displaced, or the apparatus was out of order, the engineer, seeing the danger-signal, would be governed accordingly; but, on the contrary, if the safety-signal appeared when the train reached the proper point, it showed that both the track and the electric apparatus were in order.

Another device of the same inventor rang a bell at a railroad crossing when a train arrived within a certain distance.

A continuous line of signals at fixed intervals of a mile or so apart, upon the closed-circuit plan, has also been devised.

The wear and tear in the operating mechanism of signals of this kind, occasioned by the frequent passage of heavy trains at high rates of speed, being very great, it has been proposed to use the rails themselves as a telegraph line for this purpose, the circuits being made by the iron wheels as they pass over the intervals separating the ends of the rails at the joints. Mr. F. L. Pope says that he has tried an arrangement of this kind on the Boston, Lowell, and Nashua Railroad, and that it was almost absolutely certain in its results during an experience of five months.

Rail'way-slide. (*Railway Engineering.*) A device for shifting a car from one line of rails to another. It consists of a platform running on wheels transversely across the tracks. The car is run up an inclined plane on to the platform; the latter is then moved transversely, and the car descends the incline on to the other track.

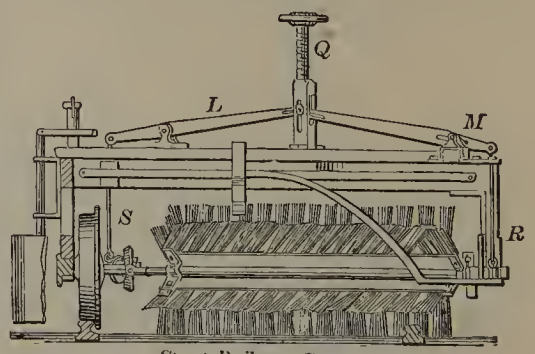
Rail'way Speed-meas'ur-er. An instrument for determining the speed of railway-trains. Whishaw's, termed by him a *ecntimetral chronometer* or *velocentimeter*, is provided with clock-work, a dial, and index-hand, by which the rate is determined between stations at known distances apart, as $\frac{1}{4}$ mile.

Redier's *horograph* affords a means of determining whether or no a prescribed rate of speed, measured by the number of revolutions of the driving-wheel, has been maintained.

Another French invention records on a sheet of paper, once a minute and at the end of every kilometer, the speed and the distance traveled, and also the time of arrival and duration of stoppage at each station.

Rail'way-sweep'er. (*Street-Railway Engineer-*

Fig. 4141.

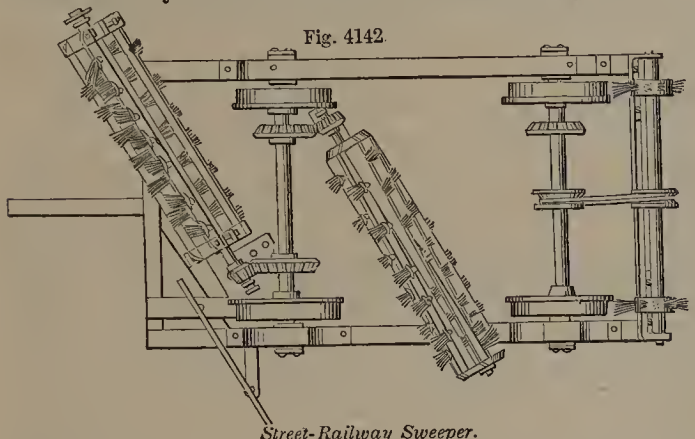


Street-Railway Sweeper.

ing.) Stationary splint-brooms at the fore part of the engine are commonly used for clearing small obstructions from the track. Rotary brushes are also used. Fig. 4141 is of this kind. It is fixed on a diagonal shaft and rotated by gear connection with the axle. By means of the screw *Q*, levers *L M*, and connecting-rods *R S*, it may be lifted out of gear and clear of the track when desired.

Fig. 4142 is a plan view, which shows the relation of the brush-cylinders to the bed and the wheels.

Fig. 4142.

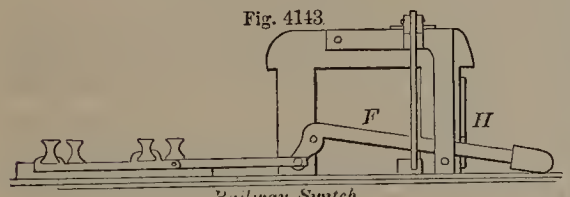


Street-Railway Sweeper.

The brushes are revolved by gearing on their shafts and on the wheel-axles, or by belt and pulleys; are adjustable vertically; may be preceded by oblique and vertically adjustable scrapers; set obliquely to clear the horse-track, or revolve in line with the rail to clear the wheel-track.

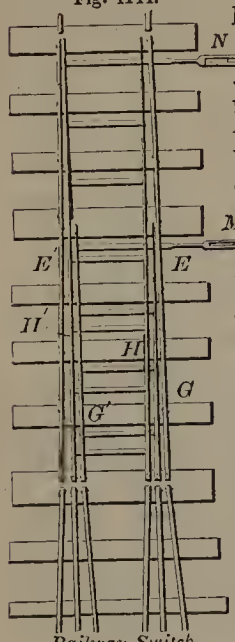
Rail'way-switch. (*Railway Engineering.*) A device for shifting cars from one track to another.

Fig. 4143.



Railway-Switch.

Fig. 4144.



Railway-Switch.

It consists essentially of a pair of movable rails united by iron straps, and pivoted at one end in continuity with a track and connected by a rod to a lever by which the other end of the pair is brought into line with either one of two or more tracks on which a train may be approaching or is intended to proceed. Various arrangements have been proposed or adopted to lessen or avoid the danger of running off the track in case the switch is not in proper position.

In Fig. 4143, the weighted bell-crank lever *F* keeps the switch-rails in line with those of the main track, and is held firmly down by a swing-catch *H* while they are in this position; the switch-rails are shifted to correspond with those of the side track by lifting the lever *F*, the catch being swung out of the way, and the lever is then held up until the train has passed. The weight on the lever causes it to automatically replace the movable rails should the switchman neglect to do so.

In Fig. 4144, the exterior rails *E E*, which connect the main line and branch tracks, are fixed. The interior long rails *H H'* are coupled, as are also the short rails *G G'*, and each pair independently connected by the rods *M N* to their respective switch-levers. In case these are misplaced, the flanges of the wheels entering the wedge-shaped openings formed by the tapering ends of the movable rails throw them into their proper positions, while the fixed outer rails prevent the cars from leaving the track. See SWITCH.

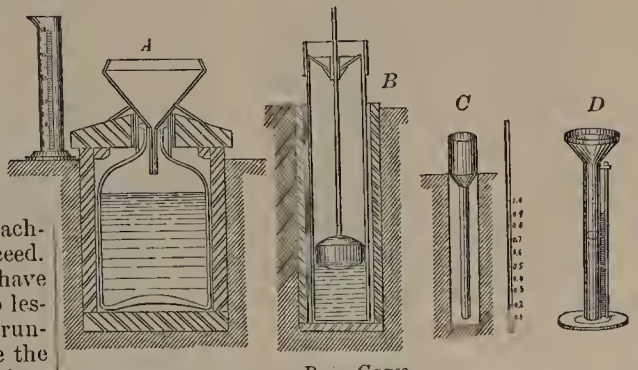
Rain. (*Pyrotechny.*) Gold-rain is composed of small, equally sized stars, about ½ inch in diameter: they appear of a golden color when burning, produced by lamp-black and flowers of zinc; and as they burn slowly, their effect in falling, particularly in large numbers from a considerable hight, is very beautiful.

Rain-cham'ber. (*Metallurgy.*) In the extraction of copper, a compartment into which spray is injected, and through which the smoke is compelled to pass, to remove poisonous vapors. Proposed by Sir Humphry Davy. See also Whelpley and Storer's patent, 1864.

Rain-gage. An instrument for measuring the amount of rain that falls on a given surface. Also called an *Ombrometer*, *Udometer*, *Pluviameter*. In Fig. 4145, *A* is a simple device for this purpose. It comprises merely a copper funnel 5 to 7 inches in diameter, inserted in the neck of a bottle placed on a stand and protected from the sun's rays, to prevent evaporation. The rain collected in the bottle is measured in a glass jar having $\frac{1}{10}$ the area of the funnel, and graduated so that a rainfall of $\frac{1}{10}$ inch collected by the funnel is measured by 1 inch on the side of the vessel. The stand should be placed at a sufficient distance from any buildings, etc., to prevent their affecting the amount falling into the funnel.

B consists of a copper cylinder, 5 to 7 inches in diameter and 2½ feet long, in which is a float of nearly the same area as the cylinder, but rising and falling freely therein. It carries a graduated rod, which rises upward as rain accumulates in the cylinder, indicating the fall in inches and decimals. Snow and hail are melted, to ascertain the amount of water which they form, the first being pressed down in the gage-funnel as it fills, if necessary.

Fig. 4145.



Rain-Gages.

The Smithsonian rain-gage *C* is of brass, and has a wooden cylinder, which is inserted permanently in

the ground for the protection and ready adjustment of the instrument. It has a graduated scale, which reads to 10ths and 100ths of an inch.

The scale may be dipped into it, or may be made to float, so as to be raised as the water accumulates, exposing the graduations on the rising rod.

Still another gage *D* consists of a large and a smaller tube connected at bottom, the smaller tube having $\frac{1}{10}$ of the sectional area of the mouth of the larger one.

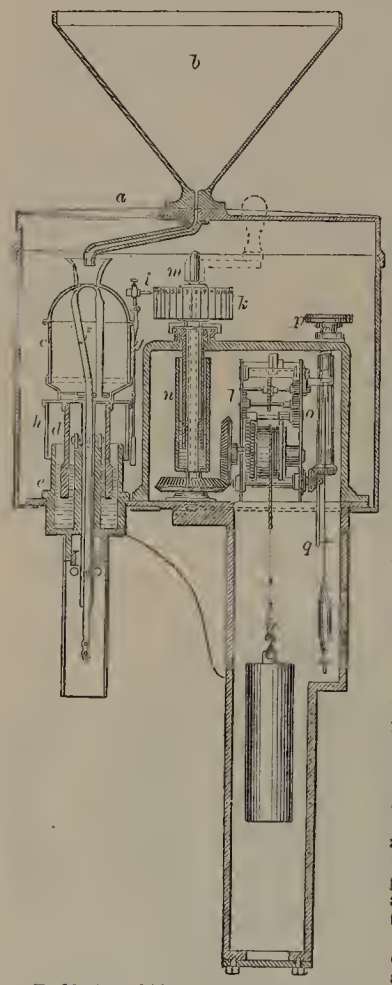
The smaller tube is graduated, and 1 inch of rise is equal to $\frac{1}{10}$ of an inch fall of rain.

The tube should be 6 inches long and 2 inches in diameter, connected with a tube $\frac{1}{2}$ inch in diameter, and with a funnel on the larger, to give it the proportions stated.

The self-recording rain-gage (Fig. 4146), a very delicate and accurate instrument, was invented by Mr. Robert Beckley, of the Kew Observatory.

a is a thin cast-iron box, about one foot square, and having a hinged top to which the funnel *b* is attached; the upper surface of this has an area of just 100 square inches. A pipe, having a strainer at its lower orifice, leads from the funnel to a copper receiver *c* supported by a hollow cylinder *d* floating in mercury contained in the annular cistern *e*. As water enters the receiver, the float *d* descends in the mercury, its area relatively to that of the cylinder being so proportioned that it descends uniformly with the admission of equal quantities of water into the receiver *c*. When the level of the water rises as high as the top of the siphon *f*, this begins to operate, rapidly emptying the receiver, which then rises and assumes its original position. As the receiver contains just 25 cubic inches, this occurs whenever $\frac{1}{4}$ inch of rain has fallen.

Fig. 4146.



Beckley's Self-Recording Rain-Gage.

The siphon *f* is contracted and flattened at its upper portion, so that the water continues to rise in its shorter leg until a sufficient head of water has accumulated above it to overcome the capillary attraction, when the flow down the longer leg commences and continues until all the water in the reservoir is discharged. Several small irregular apertures at the lower part of the siphon admit air and prevent any water being retained by capillary attraction. The long leg of the siphon, after issuing from the receiver, passes through a brass tube guided by rollers through the central part of the mercury cistern, so as to keep float and receiver perfectly vertical and central. A thin layer of fluid glycerine over the surface of the mercury prevents oxidation, and also acts as a lubricant.

A spring *g* attached to the cover *h* of the float receives at its upper extremity a pencil *i* which presses against a cylinder *k* of white glazed earthenware, rotated by clock-work mechanism, shown at *l*. The cylinder fits easily on the spindle *m*, so as to be removable and adjustable, and its circumference is divided by vertical lines into twenty-four spaces. When the record of the day is complete, it is replaced by another, and the pencil-marks made on its surface as the reservoir descends are washed off. The clock *l* is contained in a hermetically closed case, having mercurial stuffing-boxes at *n*, in which the vertical spindle revolves, by a reversal of whose movement the winding is effected, and at *o*, through which the pendulum is set in motion. This movement is effected by turning the milled head *p* rotating two bevel-wheels imparting motion to a small arm *q*, which, pressing against the pendulum-rod, forces it out of a vertical position. When pressure is removed from the milled head, the arm falls back to its original position, permitting the pendulum to oscillate freely. The clock-work mechanism employed may of course be adapted to run any number of days desired.

Crossley's rain-gage is an adaptation of his liquid meter, the parts being inclosed in a box and having a vibrating bucket whose pulsations are recorded by a train of gearing and an index-finger on a dial.

The rain-gage of the late Professor Coffin was an inverted cone, having a horizontal surface of 172.8 square inches; the rain falling into it passed down, through an orifice so small that no appreciable evaporation could occur, into a close-fitting can. One inch of rain in depth would, therefore, make $\frac{1}{10}$ of a cubic foot when collected, the weight of which is 100 ounces. Each ounce that the can contained after a storm, consequently, represented $\frac{1}{100}$ of an inch in perpendicular fall. The amount necessary to merely moisten the funnel without precipitation into the can was easily determined as a constant.

Ronalds's rain and evaporation gage has a float in a central covered vessel, which, by means of a silken cord passing over a pulley, turns an index indicating the amount of rain received in an exterior uncovered vessel communicating with the first, and having an area of one square foot, in case any has fallen between two observations, diminished by the amount which has evaporated; if no rain has fallen, the amount of evaporation only is indicated, the index turning in the opposite direction.

The amount of rain falling annually is very unequally distributed over the earth's surface, depending on many conditions. The direction of the wind, its permanence, temperature, the condition and elevation of the surface over which it passes, all exert an important influence.

High mountain-ranges intercept a large proportion, in some cases nearly all, of the aqueous vapor with which the atmosphere becomes charged during its passage over the sea, the source whence the great supply of moisture is derived, and cause it to be deposited on their windward sides, while those to leeward receive little or none.

Thus the trade-wind districts of the west coast of South America are rainless, the moisture brought from the Atlantic by these winds being in part discharged upon the eastern plains of that continent before reaching the Andes, which intercept the remainder. Proximity to the sea, when the prevailing winds are from that direction, also greatly increases the mean rainfall. In Ireland and the West of England a larger quantity falls than in Central and Eastern England; the amount at Liverpool exceeding that of London by about one half, while at Seathwaite, Borrowdale, in Cumberland, the annual fall reaches the, for that latitude, extraordinary amount of 141.54 inches; this is, however, principally due to the high ranges of hills eastward of this place.

At Sitka, Alaska, and Bergen, Norway, where both these conditions of proximity to the ocean and the vicinity of high mountains to leeward are fulfilled, the annual fall is respectively 87.9 and 88.6 inches, while at Stockholm it is 20.4, and at St. Petersburg 17.3 inches.

The whole western seacoast of America, north of latitude 41°, is from this cause characterized by an annual fall exceeding 60 inches, diminishing to $\frac{1}{3}$ of that amount and less eastward of the mountains.

Intensely heated plains, by elevating the temperature of the winds passing over them, even though saturated with vapor on their arrival, tend to prevent precipitation. Thus the desert of Sahara, Egypt, Arabia, Southern Persia, and the great desert of Gobi in Central Asia, constitute a rainless tract embracing a considerable portion of the earth's circumference. The table-lands of Thibet and Mexico, parts of California, and the great North American desert are also either entirely or comparatively rainless.

Local causes frequently determine the amount of rain which may fall in a short time at a given spot. This not unfrequently amounts to a large fraction of the annual precipitation. At London, on the 27th of November, 1845, $6\frac{1}{2}$ inches, more than $\frac{1}{4}$ of the total annual amount, fell within 24 hours.

At Joyense, in the department of the Ardeche, France, 31.173

inches have been known to fall in 22 hours; at Genoa, 30 inches in 24 hours; and at Gibraltar, 33 inches in 26 hours, — the latter equaling the total yearly fall in England and in the Northern United States.

At San Diego, California, but 5 inches fall in the course of the year. Grass Valley, in the same State, has an annual fall of 60 inches.

The tropics, as being the great source for supplying the atmosphere with aqueous vapor by evaporation, naturally constitute the great area of precipitation, though, owing to other causes modifying the normal distribution of rain, the average tropical fall may occasionally be largely exceeded in some extra-tropical places. For instance, on the Pacific coast of Patagonia, latitude 50° 55′ S., 144 inches have been known to fall in 40 days.

At Sierra Leone, 314 inches fell in four months of 1838; 20 inches of which fell in two days.

The average annual rainfall of Bengal is 200 inches; on the Bhore Ghaut, above Bombay, 220 inches frequently fall in four months.

The greatest known rainfall in the world occurs in some parts of India.

At Mahubalechoar, on the western slope of the Ghauts, 4,461 feet above the sea, the average yearly fall during a period of forty years was 275 inches.

At Cherrapoonje, at the same elevation, on the Garrow Mountains to the south of the valley of the Brahmaputra, the annual rainfall is 550 inches, which is about equal to the rainfall of a century at Alexandria, Egypt. This was even exceeded in the experience of the naturalist Hooker, who observed in some of the valleys of the Himalaya a fall of 470 inches in seven months, and 30 inches on one occasion in four hours, equal to the average annual rainfall in France. This was at Khasia, where, according to Mr. Yule, in the month of August, 1841, there fell 264 inches, or 22 feet; 30 inches falling daily during five successive days. This is attributable to the abruptness of the mountains which face the Bay of Bengal, from which they are separated by 200 miles of Jheels and Sunderbunds.

This fall is very local: at Silhet, not thirty miles farther south, it is under 100 inches; at Gowahatty, north of the Khasia, in Assam, it is about 80; and even on the hills, twenty miles inland from Churra itself, the fall is reduced to 200.

During the rainy season, from April to November, as much as 10 or 12 inches of rain falls in a day in Burmah and Siam.

The enormous rainfall of Khasia would, however, seem to be equaled in Cayenne, where Admiral Roussin reports 12 feet 6 96 inches having fallen between the 1st and 24th of February, 1820. At Cumana, in Venezuela, on the same coast, the annual amount is but 8 inches.

Latitude exerts a great effect on rainfall, the amount of vapor suspended in the atmosphere decreasing rapidly as we approach the poles, though, owing to its being discharged more equally throughout the year, the number of rainy days is generally greater than in lower latitudes.

There are six maximum points of rainfall in Europe, estimated in rainy days, not quantity, — Norway, Scotland, S. W. Ireland and England, Portugal, N. E. Spain, Lombardy.

In Ireland it rains 208 days in the year.

In England it rains 150 days in the year.

In Kazan it rains 90 days in the year.

In Siberia it rains 60 days in the year.

On the Dofrefelds of Norway it rains and mists nearly continually an aggregate of 82 inches per annum; about equal to Bombay, Havana, Sierra Leone.

Humboldt estimates the average rainfall at the equator, 96 inches; at latitude 19°, 80 inches; at latitude 45°, 29 inches; at latitude 60°, 17 inches.

According to Professor Thomson, the average number of days on which rain falls is, between latitudes 12° and 43° north, 78; between latitudes 43° and 50° north, 103, between latitudes 50° and 60° north, 161. Local circumstances, however, largely interfere with this; at Rome, for instance, there are but 64 days of rain in the year, and at Padua 120.

London has 220 dry days in the year, and Dublin but 150. The number of days of heavy rain is nearly the same at both places, — from 16 to 32 annually.

Dr. Heberden found that on top of Westminster Abbey, from July, 1766, to July, 1767, but 12.099 inches of rain fell; on top of a lower building near by, 18.139 inches; and at the ground, 22.603 inches.

At York, as determined by Phillips in 1834–35, the amount at an elevation of 213 feet was 14.963 inches; 44 feet, 19.852 inches; at the ground, 25.706 inches.

At the Paris Observatory the relative amounts falling three meters from the surface of the earth, and a station twenty-seven meters above this, were as 1.116 to 1.

The effect produced on the annual rainfall of a country by clearing it of its forests is a subject which of late years has received, as it deserves, a great share of attention. Sir John Herschel, Lyell, and the most eminent authorities in meteorology generally concur in the opinion that the tendency of cutting down the woods is to cause an absolute diminution of the rainfall. The plains of Babylonia, once so fertile, now an arid desert; the elevated plateaus of Central Spain, which in the time of the Romans yielded abundant harvests, and now afford but a scanty subsistence to sheep, — appear to owe their present sterility to this cause; while it is stated that, in Central America, lakes situated in tracts formerly cleared by the Spaniards, which had diminished in volume, have again become full on account of the increased rainfall due to encroachment of vegetable forms on this cleared land.

It is also stated that the amount of arable land in Egypt has been increased in recent times by planting palms and other trees in desert and unfertile places. The origin of some of the oases in the great Sahara desert is attributed to the same cause.

However the absolute yearly rainfall may be affected in this way, — our data do not extend over a space of time extending back sufficiently far to positively determine if there has been an important diminution in its amount since the settlement of this country, — there can be no question but the deprivation of its woody covering tends to promote evaporation from the soil, rendering it arid and sterile and causing the falling rain, which would otherwise slowly percolate through it, to run quickly off, carrying with it the lighter and more fertilizing particles to the water-courses by which they are ultimately conveyed to the sea.

This also tends to impair the permanency of flow of streams, as the water which would accumulate and be gradually discharged by means of springs, tending to moderate the extremes of high and low water, flows off at once, causing floods, immediately succeeded by intervals of extreme low water.

Some observers insist that this result has already been developed in many tributaries of the Ohio; those down which in the memory of man heavily laden arks or flat-boats were floated to a market being now entirely unnavigable.

The transitory character of the floods in the western tributaries of the Missouri, notably the Platte River, afford confirmation of the fact that inland navigation, as well as agriculture, depends largely on a sufficient growth of timber, which can alone maintain those conditions of evaporation and discharge of moisture which are most favorable to the support of man.

The following table gives the average annual rainfall, in inches, for a number of places on the globe. The figures for the United States are derived from the tables prepared for the Smithsonian Institution by C. A. Schott, Esq: —

Brunswick, Me.	44.68	Milwaukee, Wis.	30.40
Hanover, N. H.	40 32	Fort Snelling, Minn.	25.11
Burlington, Vt.	34.15	Muscatine, Iowa	42 38
New Bedford, Mass.	41.42	St. Louis, Mo.	42.18
Providence, R. I.	41.54	Fort Gibson, Ind Ter.	36.37
Fort Columbus, N. Y. Harbor	43.24	Fort Towson, Ind. Ter.	51.08
Penn Yan, N. Y.	28.42	Fort Leavenworth, Kau	31.74
Buffalo, N. Y.	33.84	Fort Kearney, Neb.	25.25
Newark, N. J.	44.85	Fort Randall, Dak.	16.51
Philadelphia, Pa.	44.05	Fort Laramie, Wyoming	15.16
Pittsburgh, Pa.	37 09	Fort Massachusetts, Col.	17.06
Washington, D. C.	37.52	Fort Garland, Col.	6.11
Baltimore, Md. (Fort McHenry)	41 10	Fort Craig, New Mexico	11.67
Fortress Monroe, Va.	47.04	Fort Marcy, New Mexico	16.65
White Sulphur Springs, Va.	37 54	Fort Defiance, Arizona	14 21
Gaston, N. C.	43.40	Salt Lake, Utah	23.85
Charleston, S. C.	43.63	Fort Bridger, Utah	6 12
Savannah, Ga.	48.52	Sacramento, Cal.	19.56
Key West, Fla.	36 23	San Francisco, Cal.	21.69
Fort Myers, Fla.	56.55	San Diego, Cal	9.16
Mt. Vernon Arsenal, Ala.	66.14	Meadow Valley, Cal.	57.03
Huntsville, Ala	54.88	Dalles, Oregon	21.74
Natchez, Miss.	53.55	Fort Hoskins, Oregon.	66.71
New Orleans, La.	51.05	Fort Vancouver, Washington Territory	38.84
Baton Rouge, La.	60.16	Fort Colville, Wash. Ter.	9.83
Fort Brown, Texas	33.44	Neah Bay, Wash. Ter.	123.35
Fort Bliss, Texas	9.56	Sitka, Alaska	83 39
Fort Smith, Ark.	40 36	Vera Cruz, Mexico	183.20
Washington, Ark.	54.50	Cordova, Mexico	112.08
Springdale, Ky.	48.58	Bermuda	55.34
Marietta, Ohio	42.70	San Domingo	107.6
Cleveland, Ohio	37.61	Havana, Cuba	91.2
Detroit, Mich	30.05	Rio Janeiro, Brazil	59.2
Mackinac, Mich	23.93	Maranham	277.00
Richmond, Ind.	43.32	Cayenne	116.00
Peoria, Ill.	41.25	Toronto, Canada	35.17
		St Johns, Newfoundland	58.30
		St. John, N. B.	51.12

To these may be added the following figures of foreign rainfall: —

London, England	24.4	Stockholm	20.4
Liverpool, England	34 5	Copenhagen	18.35
Manchester, England	35.2	Berlin	23.56
Bath, England	30.0	Mannheim	22.47
Truro, England	44.0	Prague	14.1
Cambridge, England	24 9	Cracow	13 3
York, England	23	Brussels	28.06
Borrowdale, England	141.54	Paris	22 64
Dublin, Ireland	29 1	Geneva	31.07
Cork, Ireland	40.2	Milan	38.01
Limerick, Ireland	35	Rome	30.86
Armagh, Ireland	35.12	Naples	29.64
Aberdeen, Scotland	28.87	Marseilles	23.4
Glasgow, Scotland	21.33	Lisbon	27 1
Bergen, Norway	88.61	Coimbra Port	118.8

Bordeaux	34 00	Pekin, China	26.93
Algiers	36.99	Canton, China	69.30
St Petersburg	17.3	Singapore, Malacca	97
Simpheropol, Crimea	14.83	Sierra Leone, Africa	86.2
Kutais (E. shore of Black Sea)	59.44	Uttray Mullay, India	267.2
Bakou (S of Caspian)	13.38	Madras, India	44.6
Ekatherinburg, Ural Mts.	14.76	Calcutta, India	76.4
Barnaoul, Siberia	11.80	Cherrapoonjee, India	592
		Khasia, India	610

Raised Up-on'. (*Shipbuilding.*) Having the upper works hightened; the opposite of *razed.*

Rais'er. (*Carpentry.*) The front of a step. The elevation of a step. A *riser.* The flat portion of a step is the *tread.*

Rais'ing. 1. (*Metal-working.*) The process of forming circular work or embossing in sheet-metal by striking up or raising from the interior surface.

In the case of circular works, as candlesticks, teapots, and other vessels and their covers, this is generally effected by *spinning* in the lathe.

In other cases hammering is resorted to, the metal being raised and the desired form imparted by successive blows while the plate is placed on an anvil or former, care being taken to preserve as nearly as possible a uniform thickness throughout.

Where large numbers of the same pattern are to be made, stamps and dies are usually employed. See EMBOSSING; SPINNING; STAMPING.

2. (*Printing.*) Placing scraps of paper on the tympan so as to increase the pressure at a particular point, to cause the ink to adhere more fully and give a dark impression at that point. Practiced with woodcuts. Also called *underlaying.*

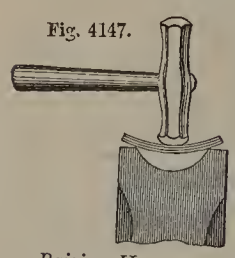
3. (*Leather-manufacture.*) The operation of swelling the pores of leather by steeping in dilute acid, in order to enable the tanning liquor to penetrate more easily.

Rais'ing-board. (*Leather-working.*) A corrugated board which is rubbed upon leather after it has been tanned, shaved, daubed, and dried, in order to *raise* the grain. A *crippler.*

Rais'ing-gig. (*Cloth-manufacture.*) A machine for raising a nap on cloth. A *gig-machine.*

Rais'ing-ham'mer. (*Metal-working.*) A long-headed hammer with a rounded face, used by silver and copper smiths to convert a sheet of metal into a bowl-shape.

Fig. 4147.



Raising-Hammer.

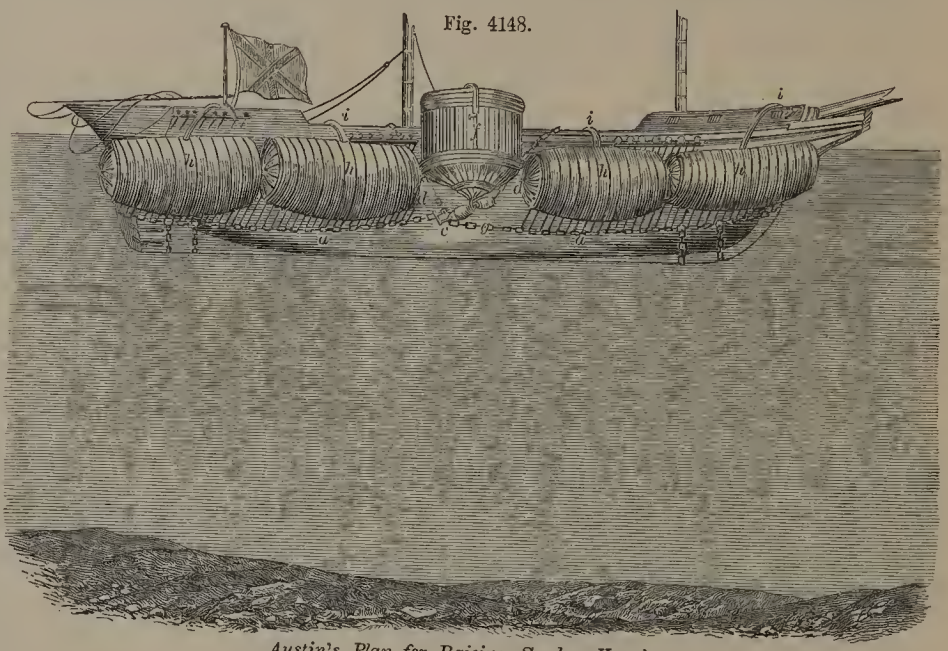
Rais'ing-knife. (*Coopering.*) A knife employed by coopers in setting up the staves in form for a cask.

Rais'ing-plate. (*Carpentry.*) That plate of a frame which rests on the vertical timbers and supports the heels of the rafters.

Rais'ing Sunk'en Ves'sels. (*Hydraulic Engineering.*) Among the various devices for this purpose may be cited: —

1. The *camel* or *caisson* submerged and chained to the vessel; the water in the caisson displaced by air, either by pumping out the water or forcing in the air; the flotative power of the caisson thus lightened lifting the vessel to the surface. The *camel* has long been used in Holland for floating vessels over the bars of rivers. The invention is credited to Bakker of Amsterdam, about 1688, the year that the great Prince of Orange came over to England and superseded the last of the Stuart kings. The *camel* consists of twin hollow vessels, so arranged that they can be applied on either side of the ship's hull. They are made water-tight, and on the deck of each windlasses are attached, by which ropes passed under the keel of the vessel are worked. Each half of the camel is allowed to fill with water, which sinks with the weight, and when the ropes are adjusted the water is pumped out, and the buoyancy of the hollow vessels lifts the ship out of its bed at the bottom of the stream.

Fig. 4148.



Austin's Plan for Raising Sunken Vessels.

The largest men-of-war were thus lifted over the shoals of the Zuyder-Zee. The camel has been used in many other places since.

A modified form consists of caissons or large barrels submerged and attached by slings to the vessel.

Captain Austin's plan differs from those described in having large inflatable canvas bags *h h h h*, rendered water and air proof by caoutchouc and strengthened by envelopes of netting. These are brought into position against the vessel by slinging the chains to which they are attached around the hull. Two tugs, taking the ends of a chain *a*, sweep the bottom where the vessel lies until the bight encounters the vessel. Buoys attached to the chain at intervals show by their position on the surface of the water the lay of the vessel. Another chain *a'* is now swept around the other end of the vessel, and rings *c* on the ends are passed over the ends of the chain *a*. A stopper *g* is sent down the chain *a* to prevent the ring slipping back. Another bag *f* is then sent down the chain *a*, the same being on each side of the vessel, and is secured by a stopper *d*. All being ready, the bags *h h h h f* are inflated by air driven

in by pumps through the pipes *i i*, which reach to the surface, and the vessel floats, as seen in the figure. The bags are secured to the main chains by smaller ones.

Colonel Gowan tried this plan in 1851 in an attempt to raise the wreck of the United States steamer "Missouri," burned and sunk in the Bay of Gibraltar in 1845. He found it ineffectual; the difficulty being, in this case, the bursting of the bags. He tried them again at Sevastopol with the same result. He removed the wreck at Gibraltar Roads by blowing it to pieces by the explosion of loaded cast-iron cylinders inserted beneath the vessel. The charges were ignited by electricity, and the portions of the wreck removed piecemeal.

2. Another mode is by slinging a vessel to lighters, which are raised by the tide, and the vessel transported to shoaler waters. The slings are shortened during the next tide, and the process repeated.

One of the earliest accounts of raising sunken vessels is that given of the raising of the "Mary Rose," by Edward Bedall of Boston, Colony of Massachusetts, 1642. She had been sunk in the previous year, and the diving-bell seems to have been used in adjusting the slings by which she was raised and transported to shoal water, where the hull, lading, and guns were recovered.

The steamer "Erie," burnt and sunk in Lake Erie in 1854, was raised by Colonel Gowan by means of chain falls working from two open-trussed frames supported upon hulks on either side.

This gentleman, under a contract with the Russian government afterward, between 1857 and 1862, raised the hulls of the vessels sunk in the harbor of Sevastopol during the siege of that place by the Allies. These were more than 100 in number.

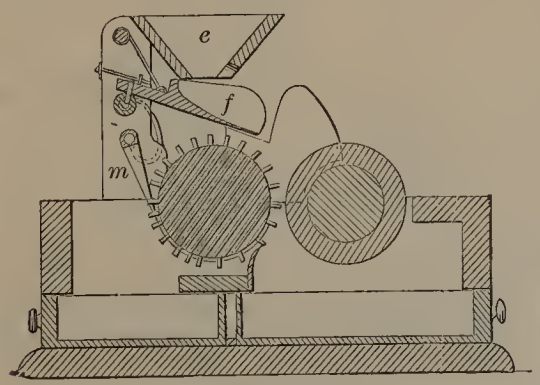
The attempt was first made to lift them entirely by means of floating caissons or docks on either side, connected by chains to the hull of the vessel. It was found, however, that, as the vessel rose, the docks, though firmly anchored, were drawn together with such force that they could not be separated even when steam-tugs and gunboats aggregating 1,000 horse-power were brought into requisition for this purpose.

A pump capable of raising nearly 1,000 tons of water per minute was then employed. This removed the water from the interior of the hull much faster than it could enter from without, the ports and other openings having been previously closed as far as possible, and by this, in conjunction with the floating caissons and a chain 1,000 feet in length, having links of some 350 pounds' weight, the work was successfully accomplished.

3. A third plan is to raise the wreck by direct hoisting power. An instance of this is Bishop's floating-derrick, shown at Fig. 1617, page 688.

4 Vafea's plan for raising sunken ships consists in first closing hermetically the hatches, port-holes, and all other openings in the deck or upper or side parts of the sunken ship, and then pumping down air to the bottom of the ship through tubes inserted either through the bottom of the ship's hull, or through the deck, each tube being passed down close to the bottom of the ship. The air thus introduced rises by itself toward the under side of the deck, and, not being able to escape, presses the water contained in the ship down and out through the hole made by accident or through holes made for the purpose. The vessel will thus be rendered buoyant, and will rise to the surface.

Fig. 4149.



Raisin Seeder.

Rais'in-seed'er. (*Household.*) A machine for taking the seeds from raisins. The example shows the usual form. The raisins falling from the hopper *e* down the spout *f* are impaled upon closely set wires on the cylinder by revolution against a rubber drum; a scraper removes the seeds from the surface, and the pulp is subsequently drawn off the wires and collected. The wires are set so closely as to force outward the seeds; these, when removed by the scraper, fall into one drawer, while the pulp removed from the wires by the rake *m* falls into the left-hand drawer.

Rake. (*Agriculture.*) An implement having a head provided with teeth and a long handle projecting from the head in a direction transverse to that of the teeth and nearly perpendicular to the head. A grain-rake works better when the teeth and handle are at an angle of about 75°. The head is put on a "little *hooking*," as it is called.

Rakes are *hand* and *horse*. Specific names indicate purpose or construction; as, hay, stubble, barley, manure, horse, tilting, drag, etc.

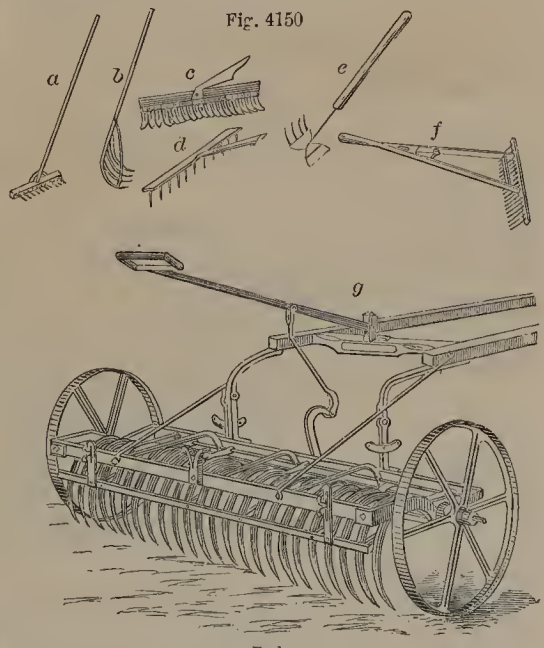
Hand-rakes are of wood for hay or grain, and of metal for garden use.

The rake is not represented in the sculptures or paintings of ancient Egypt. So says Wilkinson. The seed was covered by the plow, hoe, or by tramping of goats; probably, also, by dragging bushes over it.

The Roman hoe (*raster*, a scraper), when its blade was divided to form teeth, was known as *raster-bidens* or *quadridens*, etc., according to the number of prongs. It was the ordinary tool for stirring the ground when deep digging by the spade (*pala*) was not required.

The hay or grain hand-rake (*a*) in the United States is made of wood, and the same rake answers for either. The material will vary with the place, but the general statement may be made that the handle and head should be of a material strong in proportion to its weight, say red-elm or sassafras;

Fig. 4150



Rakes.

and the teeth of the strongest wood procurable, say hickory. In England, willow is used for the handle and head, ash for the teeth. The handle is mortised

into the head and stayed by a round rod passing through the handle and into the head, where the ends are split and wedged, or secured by pins.

b is the Japanese rake.

Grain-rakes in Britain are made of large size for raking and gleaning the stubbles; the head is 4 feet long; the teeth of iron, 4 inches long and 1½ inches apart.

One variety has wheels at the end 9 inches in diameter; the rake of the teeth is adjustable. It is used for grain or hay, and was the precursor of our more ambitious *horse-rakes*.

In Scotland, a rake is used with a jointed head 15 feet long. The handle has a cross-bar, and the implement is drawn by two men.

The garden-rake varies in size and somewhat in the kind of material. See *d f*.

Cheap rakes are cast and made malleable. Others have wrought-iron heads and wrought pins riveted thereinto. Some are light and effective, being made of steel.

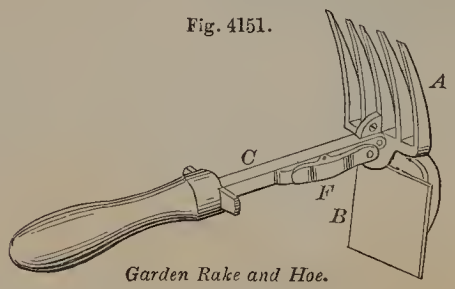
A small hand-tool (*e*) for working among flowers is made to combine a hoe-blade and a rake on respective sides of the insertion of the handle.

A rake (*c*) to take off the heads of flowers in pastures or on lawns consists of blades instead of teeth. The sharp edges cut off the flowers, which fall over the head of the rake as it is dragged along. Daisies are considered a great eyesore on English lawns, and dandelions by the neat gardeners of our own country.

This rake is in principle like the clover-headers of the nineteenth century and the wheat-harvester of Gaul, which gathered the crops of that fertile land in the first to the fifth centuries A. D.

Fig. 4151 has a rake *A* and hoe *B* pivoted on the shank *C*; either of these may be turned down on

Fig. 4151.



Garden Rake and Hoe.

the shank, when the other can be used as a fork or a spade. A latch *F* serves for locking in either of the above positions.

Horse-rakes are of several kinds, and have come into extensive use of late years. The mower, horse-rake, and horse hay-fork are a most effective trio in the business of cutting and saving hay.

Horse-rakes are wheeled or wheelless. Some rake-heads revolve, as in the old *flop-over* rake; in others, the rake-head is formed by or attached to the axle or trails behind it, and the teeth are only lifted to deliver the hay. In some the teeth are independent, so as to yield to obstacles without affecting the operation of other teeth. The rake-head is in some cases turned by hand at the proper moment, but is more commonly arranged to receive motion from the power of the animal when a holding device is released by the driver.

Howard's horse-rake (English), *g*, Fig. 4150, is thus described by the makers: —

"It is intended for raking hay, corn, stubble, or twitch-grass. The shaft-irons are furnished with a joint and quadrant, by which the teeth may be readily altered, so as to rake upon their points, or set more or less off the ground. This method is to prevent the rake collecting the soil and rubbish with grain, an objection frequently raised against the use of horse-rakes; the teeth, being curved or sickle-formed, are much stronger than when angular, and the hay and grain work round them much more freely; the bar running under the teeth, and by which they are raised, is so arranged that the teeth do not, as in other rakes, rest upon it, but allows them to drop into any hollows of the land. The frame and teeth are made entirely of wrought-iron; the teeth work independently of one another, so as to adapt themselves to irregularities of the surface. It is mounted on high wheels, which are capped to prevent the hay working round the axles.

"By means of a pull-down lever, which requires only the strength of a boy to manage, the rake can be emptied of its load without stopping the horse; the frame, being made of iron instead of wood, allows the wheels to be brought about a foot nearer together, which is an advantage in narrow lanes and gateways."

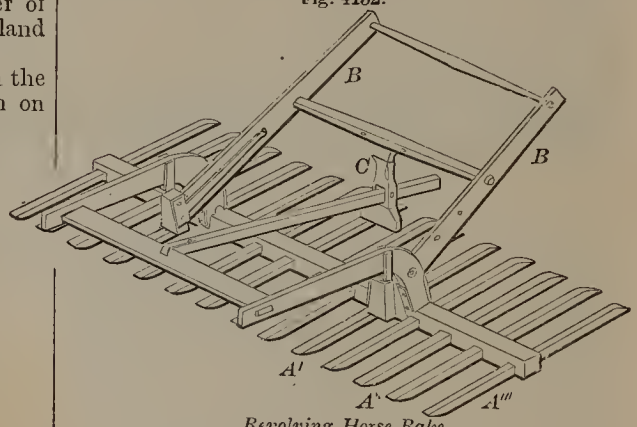
This rake is recommended for dragging-in clover-seed in the spring, and for covering other grass-seeds; also as a stubble-rake.

Horse-rakes are classified as follows: —

Rakes.....	Horse-rakes.	Revolving.	By operator.
		Lifting.	By draft.
	Hay-drags.		
	Hay-cockers.		

Fig. 4152 is an illustration of the revolving-rake, operated by a person walking in the rear and holding the upper round connecting the bars *B*. The teeth *A′ A″ A‴* and the others in the series rest nearly level upon the ground, the block *C* preventing the rake from tilting as long as pressure is kept on the bars *B B*. When a sufficient quantity of hay has accumulated on the forward part of the rake, the bars are lifted, tilting the rake and allowing the forward ends of the teeth to catch in the ground, at the

Fig. 4152.

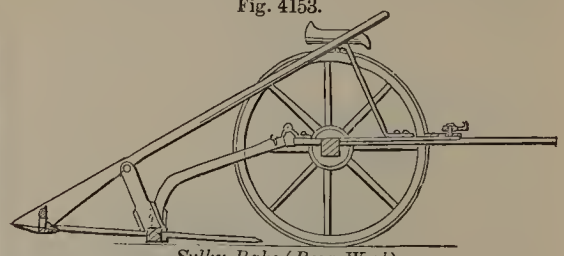


Revolving Horse-Rake.

same time withdrawing the block *C*, which acted as a detainer. The rake revolving discharges its load, and the other row of teeth comes into action.

Fig. 4153 is another form of the revolving-rake, in which the operator rides and manages the rake by

Fig. 4153.

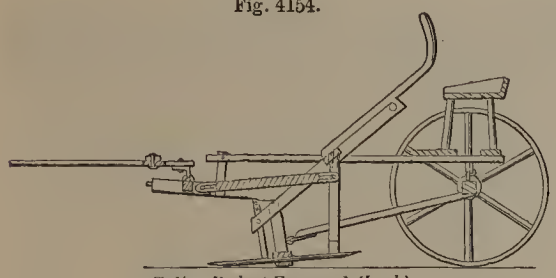


Sulky-Rake (Rear Work).

means of a lever, by which the rake is kept to its work, or is tilted as occasion requires.

Fig. 4154 is another view of a sulky-rake, on the revolving principle, in which the working portions are in front of the driver. By the operation of the lever the stop is lifted from the rear ends of the

Fig. 4154.

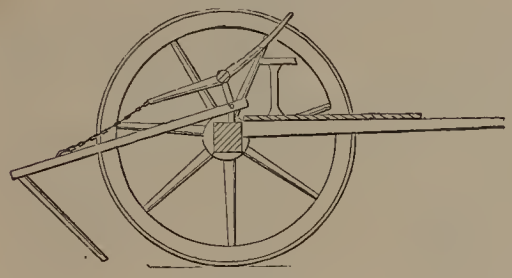


Sulky-Rake (Forward Work).

teeth and the front end tilted down, so as to catch in the ground and revolve the rake.

Fig. 4155 is a rake of the tilting order, the rake-bars trailing behind the axle and being raised as

Fig. 4155

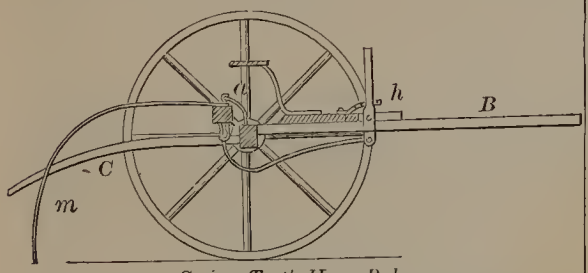


Tilting-Rake.

occasion requires to drop a load of collected hay. The rakes fall by gravity, and are raised by lever and chain.

Fig. 4156 is a spring-tooth rake. The rake-axle is connected by a bent arm with the lever *h*, pivoted to the thill *B*, and held by a notch in a segment-

Fig. 4156.

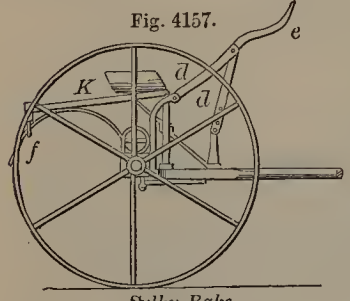


Spring-Tooth Horse-Rake.

rack. When the lever is released therefrom, the draft causes the axle to turn on its hinge-joint *a*, raising the teeth *m* from the ground, and discharging the hay by its own weight and the action of clearers *C*.

In Fig. 4157, the rake-head is partially revolved to deposit a windrow by pushing forward the lever *e* and turning the lever back; the toggle-levers *d d* turn the rake down for gathering, and lock it fast. The teeth are cleared by a series of bars *K*, having pins *f* which pass between them.

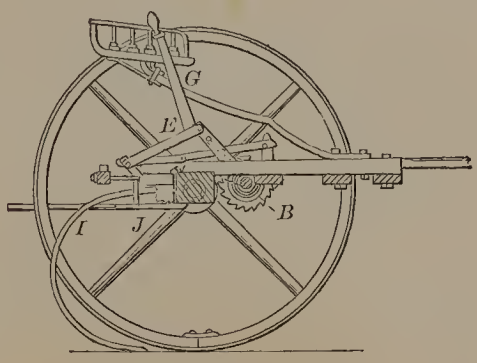
Fig. 4157.



Sulky-Rake.

In Fig. 4158, the teeth *I* are held in raking position when the lever *G* is thrown backward, as shown. On being pushed forward, it, through the medium of a series of connected levers *E*, lifts the teeth, which are then thrown quickly upward by the action of a spring *B* on the end of

Fig. 4158.



Horse-Rake.

one of the series. The spring surrounds the axis of a ratchet-wheel, by which its tension may be adjusted. Horizontal bars *J* passing between the teeth free the hay therefrom.

Another form is that of a wheeled rake with oscillating teeth elevated by a spring at the will of the operator, the spring being wound or set by the motion of the wheels, while the teeth are held in working position by an automatic spring-catch. This is tripped by the driver's foot, and the springs then operate to instantaneously elevate the teeth and support them while dropping a bunch of hay, or going to and from the field. By actuating a hand-lever, the springs are released, and the teeth then drop by gravity.

2. (*Nautical.*) *a.* The backward slope of a mast.

b. The forward pitch of the stem.

c. The backward slope of the stern, by so much as it overhangs the keel. The *rake* of a rudder is that of the stern-post.

Rak'er. (*Bricklaying.*) A piece of iron having two points bent at right angles, used for picking out decayed mortar from the joints of old walls preparatory to replacing it by new mortar. Technically termed *pointing*. See Fig. 4109.

Rak'ing-mold'ing. (*Building.*) A molding in an inclined position, as on the under side of a stairs baluster, etc.

Rak'ing-pie'ces. (*Bridge.*) Pieces laid upon sills supported by the *footings* or *impost* of a pier. Above them are the *striking-plates*, which support the ribs of a bridge *centering*, and which are driven in to allow the centering to drop clear of the completed arch. See Centering.

Ram. 1. The heavy weight of a pile-driving machine. Otherwise called the *monkey*.

2. The piston of the large cylinder of a hydraulic press.

3. A water-raising device in which the concussion produced by arresting a descending body of water is made to force a smaller quantity of water to a hight greater than the fall. See Hydraulic Ram.

4. A steam-hammer used in connection with the *squeezer* in *setting up* the *bloom* as it is lengthened by the action of the squeezer.

5. A warlike implement, formerly used, consisting of a spar with a heavy metallic head (*aries*) swung from a frame and used to batter down walls or mash gates.

6. (*Shipbuilding.*) A spar, hooped at the end, and used for moving timbers on end by a jolting blow.

7. (*Nautical.*) A projecting device at the bow of a war-vessel, designed to crush in the sides of an adversary by running against her "end on."

It formed a very important means of offense in ancient naval warfare, the prows of galleys in former times having been, as may be seen by the examination of old coins and sculptures, generally furnished with rams.

At the battle of Salamis, 480 B. C., Queen Artemisia, an Asiatic Greek herself, though allied with the Persians, effected her escape by running down a Persian ship, causing the Greeks to mistake her galley for one belonging to their own fleet.

The term *ram* is also applied to a ship provided with such an appendage.

The great ship of Ptolemy Philopator had two heads, two sterns, and seven beaks, one of which was longer than the others.

With the introduction of armor-plating the use of the ram has been revived in modern warfare. The first effective use made of it was by the Confederate "Virginia," the captured "Merrimac," sinking the United States ships "Cumberland" and "Saratoga," in Hampton Roads, March 9, 1862.

In the naval engagement at Lissa, in July, 1862, the Austrian admiral's ship "Archduke Ferdinand Maximilian" sank the Italian iron-clad "Re d'Italia" by a well-delivered thrust of her ram.

One of the rams built on the Clyde, in Scotland, for the Confederate States, but afterward purchased by the British government, is thus described by the "Liverpool Courier": "The iron hull has a coating of 10 inches of teak, and armor-plates 4½ inches thick, nearly the whole length of the side, but tapering in thickness at bow and stern. The topgallant rail of the bulwarks is of wood, and removable, the bulwarks proper being of iron, hinged on the deck level, and falling outwardly against the ship's side, thus literally 'clearing for action,' and giving the guns in the turrets an uninterrupted sweep, except directly fore and aft. The muzzles of the guns are only a little above the deck level, and the tops of the cupolas are but 5 feet high, so that they do not present a very conspicuous mark. The turrets extend some depth below, and have thus the protection of the ship's sides. What is exposed above the deck has 5½-inch plating, doubled near the muzzles of the guns, and 14-inch teak backing. The turrets are 18-sided in the surface presented to shot.

"There are two turrets, each to carry two 12-ton guns, ranged side by side, and throwing a 156-pound spherical shot, or a 300-pound bolt, if the weapons are rifled. The tower rests on a turn-table, running on wheels, the motion being obtained by four crab-winches, acting on a toothed rim fixed to the keelson that supports the tower. The tower is prevented from shifting by a wrought-iron central spindle, bolted into the framework and bed of the vessel. Outside, the towers are 24 feet in diameter; inside, 19 feet. The charge and projectile will be handed up to the gun by means of tackle, these turret guns being positively easier to work than ordinary broadside guns, while the men are all under cover of the armor-plating. Aim is taken from the outside of the turret. For this purpose there are three little holes in the roof for the gunner to put his head through, filled with iron bonnets to glance off rifle bullets. The gunner, in fact, brings the port-holes of his turret to bear upon the object.

"The dimensions of the 'Scorpion' (and 'Wyvern') are: Length on water line, 224 feet; beam, 42 feet 6 inches; depth, 20 feet; measurement, about 1,890 tons. Their great beam gives these vessels wonderful stability as floating batteries. The screw-propeller is 14 feet in diameter, and has three blades."

The Confederate ram "Tennessee," in the extraordinary fight with nearly half our entire fleet, which took place inside the harbor of Mobile, proved herself one of the most formidable crafts for harbor defense which has ever been constructed. Her hull was originally intended for a man-of-war, and was put together in a most stanch and substantial manner. Her length was about 180 feet. In form she was a modification of the old "Merrimac." Her armor consisted of 2½-inch iron in bars 8 inches wide crossing one another and bolted down with 1¾-inch bolts, making five inches of solid iron. This again was backed by 2 feet of solid oak through the entire portion of the boat above the water-line, and extending some feet even below that. From her forward casemates forward, including her pilot-house, an additional inch of iron was given her, making 6 inches of plating, and an additional foot of wooden backing, making 3 feet at this part of the boat.

Her gun-room, if that be the proper term to use, occupied about two thirds of her length, and was constructed with a flat top composed of 2½ by 8 inch iron bars, crossed and bolted together, forming a close lattice-work above her gunners, and affording ventilation while in action. The sides were inclined like those of the old "Merrimac," and through them, in the fight with our fleet, no ball succeeded in penetrating. Her ports, of which there were two on either side, and one fore and aft, were closed by means of iron shutters, which revolved upon a pivot in the center of one side, and were worked by means of a cog-wheel on the inside. They were liable, however, to derangement, and in the engagement with our fleet two were actually so deranged as to prevent their being opened, while a third, the after one, was shot away entirely, the pivot on which it revolved being broken off, and it was through this that the fragment of shell entered which wounded Admiral Buchanan, as he was standing near, directing a gunner to clear away some splinters with which it had become filled. Ten shots struck in close contiguity to this port, which it was early discovered it was impossible for her crew to close, and this really became the heel of Achilles to the fated "Tennessee." Somewhere between forty and fifty shots struck her during the fight in nearly every part of the boat, but not one penetrated her impervious armor. One 15-inch shell from the monitor "Manhattan," as is supposed, made a deep indentation which must have caused her to stagger, but bounded off from her ribs of steel. The impact of the blow, however, stove through her two feet of wooden blocking, and produced inside all the evidences of the missile's having come through. The splinters flew promiscuously in all directions in the neighborhood inside. The ram was armed with two 7 and one 8 inch rifled guns of the Brooke pattern, fore and aft, and with four of the same 6-inch guns in her broadsides.

The attack by Lieutenant W. B. Cushing upon the Confederate ram "Albemarle," in the Roanoke River, was made October 28, 1864. With a tug rigged with a torpedo spar, he ran the gantlet of the batteries and destroyed the ram, his own vessel being sunk in the encounter. The gallant commander and one seaman escaped. Lieutenant Cushing died December 24, 1874, aged 32.

Ram-block. (*Nautical.*) A block without sheaves for the lanyards of the shrouds. See DEAD-EYE.

Rămed. (*Shipbuilding.*) Said of a ship on the stocks when the frames, stem, and stern-post are up and adjusted.

Ram-head. (*Nautical.*) An old name for a halyard-block.

Ram-line. (*Nautical.*) A line used in striking a straight middle line on a spar, being secured at one end and hauled taut at the other.

Ram'mer. 1. (*Fire-arms.*) *a.* The rod by which the charge is forced home. See RAMROD.

b. A staff having a cylindrical or conoidal head attached, used in cannon for the same purpose. The rammer-head is made of beech, maple, or other hard wood not easily split, and is bored for about two thirds of its length to receive a tenon on the staff. For rifled guns or for hollow projectiles, its face is countersunk.

Rammers for large guns are technically termed *rammers* and *staves*. For field artillery, a *sponge* is attached to the other end of the staff, and the combined implement is called a *sponge and rammer*.

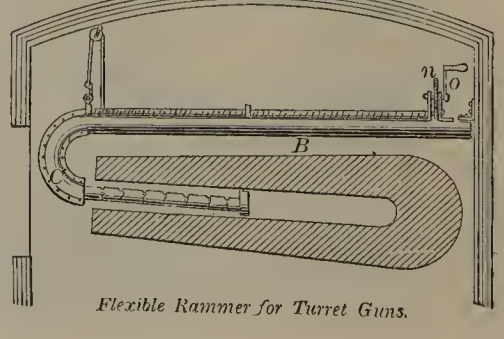
The sponge is made of coarse, well-twisted woolen yarn, woven into a warp of strong hemp or flax thread, after the manner of Brussels carpet.

They are woven in threads with selvages between them, which, being cut, the sponges are sewed to fit formers of the same diameter as the sponge-heads.

Hair sponges, frequently called brush-wipers, are sometimes employed, and are very useful, for cleaning the grooves of rifled guns.

Fig. 4159 is a flexible rammer for turret-guns. It is attached to the monitor turret by a hinge, so as to be lowered into ser-

Fig. 4159

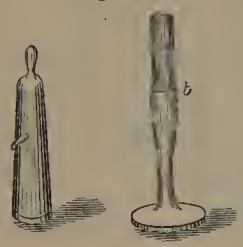


Flexible Rammer for Turret Guns.

viceable position when required. It is composed of a tube *B* surrounding a series of jointed plates *C*, which can be flexed in one direction, and are caused to protrude from the tube and follow the bore of the gun by means of a screw operated by a hand crank and gear *n o*, or other suitable mechanism.

2. The pavior's rammer (Fig. 4160) is used in settling paving-stones firmly into their beds. The rammer is used by a motion in direction of its length, as in the annexed illustration, in the ramrod of the fowling-piece, the gun-rammer, or even, in the largest sense in which the word is used, the ram of a steam-vessel brought into action by the motion of the vessel end on upon the enemy's ship. See RAM.

Fig. 4160.



Rammers.

3. (*Founding.*) A tool for ramming the sand into the flasks. They are of two kinds; square and round. The former is thin and calculated to affect the bottom of the soft sand, compressing and driving it into the interstices of the pattern. The round or flat rammer (*b*, Fig. 4160) hardens the upper surface only; it is always used last. Rammers are sometimes entirely of iron; they are best made with ash or hickory handles, about four feet long, shod with a cast-iron end of suitable size and weight. Bench-rammers have short handles.

Ra-mo-neur'. A chimney-sweeping device.

Ramp. 1. (*Fortification.*) An inclined road in a fortification leading from one level of the enciente to another. See BASTION.

2. (*Carpentry.*) A concavity on the upper side of a hand-rail formed over risers, or over a half or quarter space, by a sudden rise of the steps above.

Ram'pant Arch. One whose abutments spring from an inclined plane.

Ram'part. (*Fortification.*) An embankment around a fortified place. In the more perfect condition the wall of the rampart forms a scarp and is crowned by the parapet. See INTRENCHMENT; BASTION.

The term *bulwark* is sometimes applied to a rampart, and sometimes to an outwork for the defense of the main work.

Ram'rod. A rod of wood or metal, used for forcing the charge to the bottom of a gun-barrel, and also with a *wiper* or *ball-screw* attached, for cleansing the interior of the barrel and for withdrawing a charge. It is held to the gun by thimbles or by grooves in the band and a corresponding groove in the stock.

Wooden ones are now only used for sporting arms. The iron ramrod did not supersede the wooden one until 1742. It was introduced into the Prussian army by Prince Leopold, of Anhalt-Dessau.

The United States service ramrod, used prior to the introduction of breechloaders, is made of steel. Its parts are: —

The stem.	The thread.
The head.	The cap.
The cup.	

It generally is made with a swell, to keep it in place; but in some patterns a spring in the stock serves this purpose, and the swell is dispensed with.

Ramrods, in the large gun-factories, are made by machinery In the case of wooden ones, the blanks are driven through tubular cutters, which bring them to a cylindrical form. The iron ones are cut from a round rod. For polishing, they are placed upright in a frame which holds ten at a time, and are subjected to the action of hard-wood rubbers supplied with oil and polishing-powder. The grooved ends of the rubbers are pressed against the ramrods by springs, and the rubbers receive a rapid motion while the ramrods are slowly revolved.

Rams'den's Eye-piece. The *positive* eye-piece, principally used in micrometers, and invented by Ramsden, a celebrated instrument-maker in England (1735 – 1800).

His name is associated with science as the maker of the celebrated dividing-engine, and he is known by a number of his instruments, of great accuracy, in several European observatories, — sextants, telescopes, and mural circles.

The *Ramsden eye-piece* has two plano-convex glasses, each of which presents its concave side to the object-glass. See POSITIVE EYE-PIECE.

Ran. 1. (*Rope-making.*) A reel of 20 yarns.

2. (*Nautical.*) Yarns coiled on a spun-yarn winch.

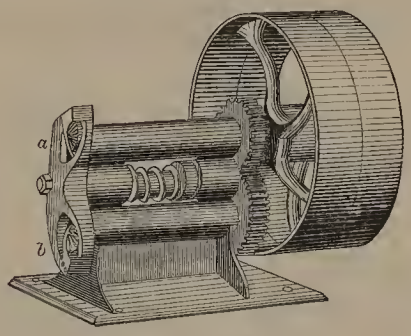
Rand. (*Shoemaking.*) One of the slips beneath the heel of a sole, to bring the rounding-surface to a level ready to receive the *lifts* of the heel.

Ran-dan'. (*Nautical.*) A mode of rowing with alternate long and short oars.

Rand-form'ing Ma-chine'. A machine which operates upon a skived rand-strip, to bend it into the circular (horseshoe) form suitable for its place in the heel of a shoe.

In Fig. 4161, the rand-strip is passed in at the orifice *a* shown at the upper left-hand corner of the

Fig. 4161.

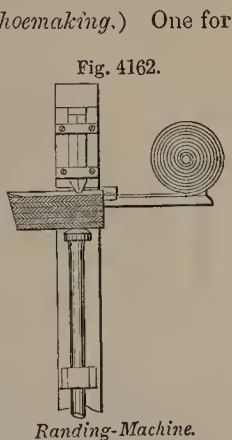


Rand-Forming Machine.

engraving, and seized between two steel formers, one of which is held up against it by the central shaft, around which it is bent as its thin edge is crimped by the formers. The strip is kept in a curved path by a guide, and released by a stripper at the lower opening *b*, properly crimped and curved for application to the heel.

Rand'ing-ma-chine'. (*Shoemaking.*) One for fitting rands on heel-blanks, to give the cup shape to the upper part of the blank. In the example, the machine consists of a heel-supporting post, a feeding and nailing mechanism, an edge-guide, and a rand-guide, by which the rand-coil or ribbon is directed and placed in position to be nailed upon the heel.

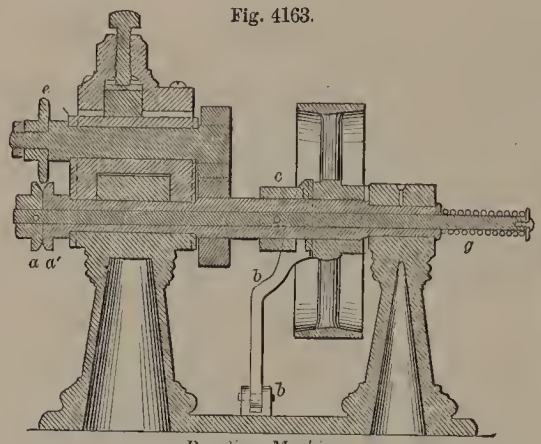
Fig. 4162.



Randing-Machine.

In Fig 4163, the forming cams *a a'* are made of shape to fit the bevel of the heel, and their inner sides are beveled to fit the bevel of the rand, which is passed upward between them, and rests against *a'*. The operator then depresses a treadle *b*, which swings back the starting-lever *b*, releasing the clutch-ring *c*, when the spring *g* throws the center-rod to the right, closing the cam *a* against the rand and engaging the clutch-ring *c* with the end of the pulley *d*, and causing the shafts to rotate. The cam *e* runs on top of the rand, forcing it between the cams *a a'*, which press it into the desired form. When the shaft has made one revolution, a lug on the ring runs on to the beveled end of the lever *b*, whereby the ring and center-rod are carried

Fig. 4163.



Randing-Machine.

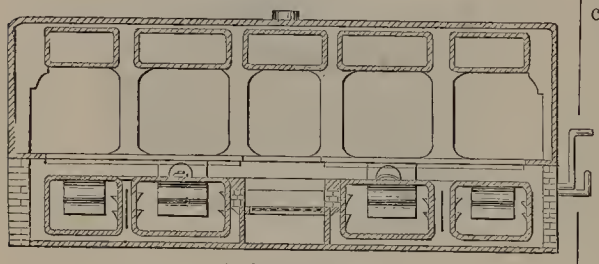
far enough to the left to disengage the clutch-teeth and separate the cams, so that the rand may be disengaged therefrom.

Rand'ing-tool. (*Shoemaking.*) One for cutting out slips of leather to form *rands*. The slip is cut into lengths, which are crimped into a horse-shoe shape.

Range. A fireplace cooking-stove, usually bricked in at the sides, but sometimes portable.

Fig. 4164 has a middle fire-chamber and two ovens at each side. By means of dampers the heat is di-

Fig. 4164.

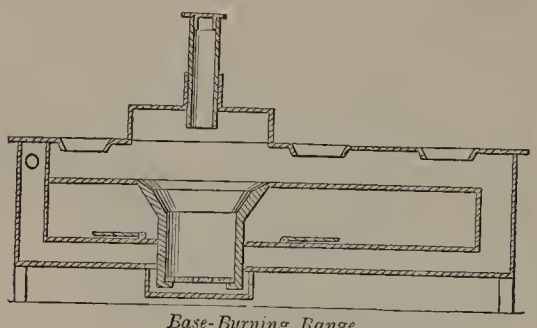


Cooking-Range.

rected to as many as may be necessary. Elevated ovens are encircled by the flues above.

In Fig. 4165, the base-burning grate is fed from a cylindrical covered tube which slides in a suitable vertical tube fixed at the back part of the top plate.

Fig. 4165.



Base-Burning Range.

The radiating heat from the fire may be used by a reflector oven attached before it.

Fig. 4166 is a portable range having a central broiling-chamber, side ovens which can be utilized by means of dampers, and a hot-closet above.

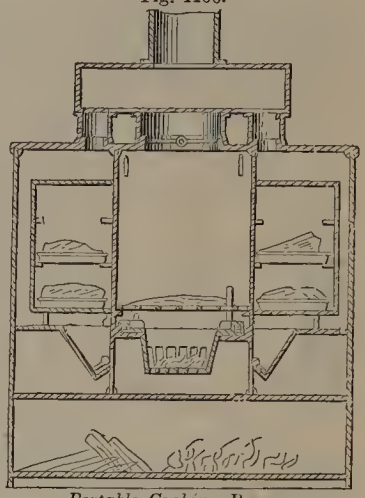
Fig. 4167 gives a sectional elevation and a horizontal section of a range, showing the various parts. The grate has a water-back *D* and a horizontal flue *II* extending backward beneath the lower oven to the upright flue, which has forward projections between the ovens and a warming-shelf. Hot-air spaces occupy room on each side of the ovens.

2. (*Ordnance, etc.*) The horizontal distance to which a projectile is thrown.

Strictly, the distance from the muzzle of the gun to the second intersection of the trajectory with the line of sight.

3. A ladder step.

Fig. 4166.



Portable Cooking Range.

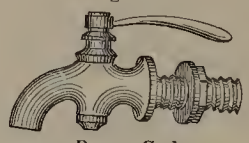
4. (*Nautical.*) *a.* A length of cable a little in excess of the depth of water, roused up out of the *tier* and ranged on deck ready to run out of the hawse-hole when the anchor is cast.

b. A large cleat in the waist for belaying the sheets and tacks of the courses.

Horned ranges; two-pronged cleats or kevels.

Range-cock. A faucet for

Fig. 4168.



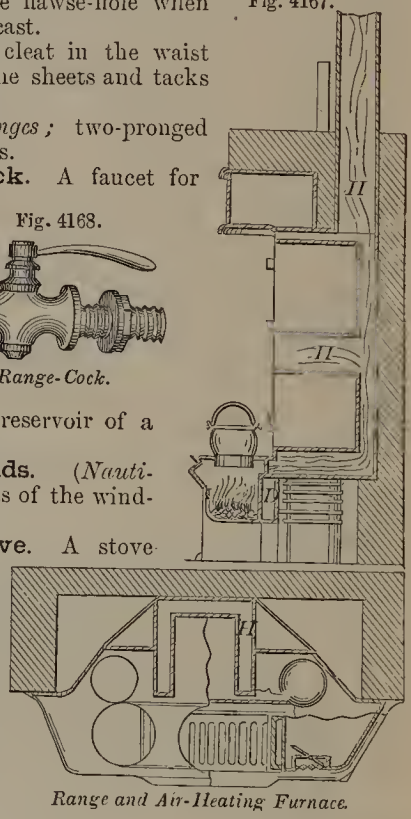
Range-Cock.

the hot-water reservoir of a cooking-range.

Range-heads. (*Nautical.*) The bitts of the windlass.

Range-stove. A stove made in the form of a range, that is, with lateral extension, ovens, and boilers, as the case may be, on each side of a central fire-chamber.

Fig. 4167.



Range and Air-Heating Furnace.

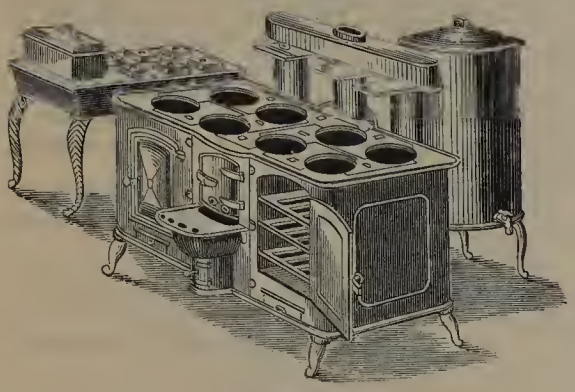
The example (Fig. 4169) is a *portable range*, or *range-stove*, adapted to be set out upon the floor of a kitchen, instead of being built into a recess in the wall, beneath the chimney.

Rap. A lay or skein, containing 120 yards of yarn. See LAY; YARN; HANK; REEL.

Rape. A filter used in a vinegar manufactory to separate the mucilaginous matter from the vinegar. It derives its name from being charged with *rapes*, the stalks and skins of grapes from which the *must* has been expressed.

Raph'i-an-kis'tron. (*Surgical.*) An instrument used in the formation of an artificial pupil for the eye. See IRIDECTOME, page 1195. See PUPIL, ARTIFICIAL.

Fig. 4169.



Range-Stove.

Ra'pi-er. (*Arms.*) A sharp-pointed sword, designed for thrusting. The blade has a lozenge-shaped section.

Ras'ing-i'ron. (*Nautical.*) An iron to clean old oakum out of the seams previous to recalking. A *reeming-iron* is for opening the seams to receive oakum. A *rave-hook.*

Rasp. An abrading tool of the nature of a file, but having, instead of chisel-cut teeth, its surface dotted with separate protruding teeth, formed by the indentations of a pointed punch.

It is used almost exclusively upon comparatively soft substances, as wood, horn, and the softer metals.

This, like many other mechanical devices, is found in the animal kingdom. Some mollusks have rasp-like tongues, by which they penetrate the shells of others for the purpose of feeding upon them.

The wasp carries a rasp, and with it abrades dry wood to obtain fiber, which becomes mixed with glutinous saliva, and forms the pulp of which so "skillfully she builds her cell." This dries into *paper*, and has a very considerable tenacity. Hornets' nests pendent from trees, varying in size from an orange to a half-barrel, are familiar objects, and are the most beautiful structure to which we can point as being formed of *raspings*. These insects also remove fibers of weather-beaten wood with their feet.

The rasp of the Tahitians, when visited by Captain Cook, was a piece of coral, — no mean substitute for one of metal. The teeth of the rasps used by cabinet-makers and farriers are cut in lines sloping from left to right; those for last-makers and some others, in the reverse direction; and for gun-stockers and saddle-tree makers they are disposed in curved or crescent-shaped lines. These distinctions are unnecessary, the only requisite being that each tooth should be intermediate between the two in front of it, so as not to form furrows in the work.

The rasp-cutting machine resembles the file-cutting machine (which see) in the striking and feeding parts, differing mainly in the several devices by which it is adapted to the cutting of rasps instead of files. To this end, the chisel-stock is pivoted to the rock-shaft so that the chisel may be vibrated, not only in a vertical plane, as usual, but also in a horizontal plane, thus cutting the teeth in curved lines across the blank. The forward feed motion is intermittent, taking place only after the completion of one row of teeth and before the commencement of another.

Rasp'a-to'ri-um. (*Surgical.*) A rasp used in rasping bones for surgical or anatomical purposes.

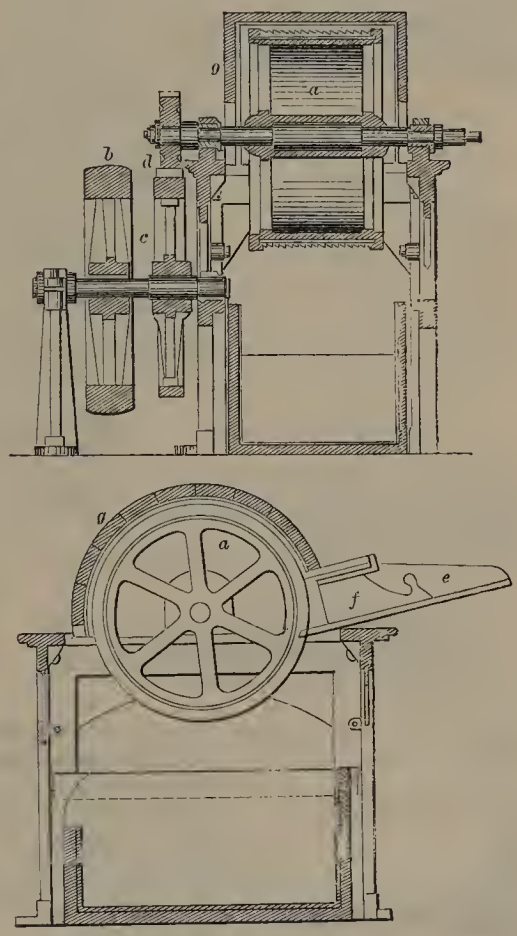
Rasp'a-to-ry. (*Surgical.*) An instrument for rasping bones. A *scalprum.*

Rasp'er. (*Baking.*) A file for rasping the burnt surface from loaves of bread.

Rasp'ing-ma-chine'. 1. A machine for rasping wood and bark for making dyes, tinctures, etc. See also BARK-CUTTING MACHINE, etc., Figs. 561, 564, 565, 566, 567.

2. A machine for grating beet-root for sugar. It consists of a drum *a* having its periphery set with saw-blades, and to which revolution is imparted by the pulley *b* through the gears *c d.* The cast-iron feed-plate *e* is divided by a ridge into two parts; the beets are placed on it and pushed up against the revolving rasp by wooden blocks *f*; a semicylinder of wood *g*

Fig. 4170.



Mechanical Rasp for reducing Beet-Root to Pulp.

lined with sheet-iron covers the upper part of the rasp; the pulp is received in a trough beneath.

Rasp'ing-mill. A saw-mill for reducing dye-woods to dust.

Rasp-punch. A tool for cutting the teeth of rasps; it is held in the left hand of the workman at a suitable angle to the face of the blank, and struck with a mallet.

Fig. 4171.

Rasp-Punch.

Ratch. A rack-bar with inclined angular teeth between which a pawl drops.

A circular *ratch* is a *ratchet-wheel.*

Ratch'et. The detent which falls into the interdental spaces of a ratchet-wheel, rising, as the wheel revolves, in one direction and preventing the backward motion of the wheel. (See RATCHET-WHEEL.) A pawl. A click.

Fig. 4172.

Ratchet and Click.

If employed to *move* the wheel, it is a *pallet.*

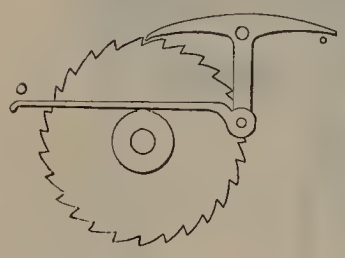
The applications of the ratchet are very numerous. It is used in connection with *pawls* in hoisting

mechanism, capstans, windlasses, and winches; with *clicks*, in the winding mechanism of most machines which are actuated by springs; in machines where a rotary motion is obtained by impulses derived from an intermittent reciprocator, as in many feed motions; in most escapements in connection with *pallets* on the axis of the balance or on the anchor.

The terms *pawl*, *click*, *pallet*, have therefore special significations, indicating relation or function.

Fig. 4173 is a device of this kind, designed to prevent reverse motion of the shaft in sewing and other machines. It is so arranged that, while the wheel to which the pawl is connected revolves in the proper direction, the pawl does not interfere with its motion; but the instant the wheel commences to turn in a contrary direction, the pawl is made to engage with its ratchet, and the reverse motion is prevented.

Fig. 4173.



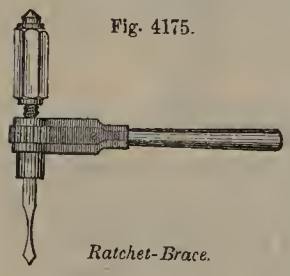
Ratchet and Pawl.

Ratch'et Bed-key. A wrench which has a ratchet on the socket or square, which engages the head of a bolt. As the handle is vibrated in one direction the spring-pawl turns the ratchet and spindle, and in the reverse motion the pawl snaps back over the teeth of the ratchet.

Fig. 4174.

Ratchet Bed-Key.

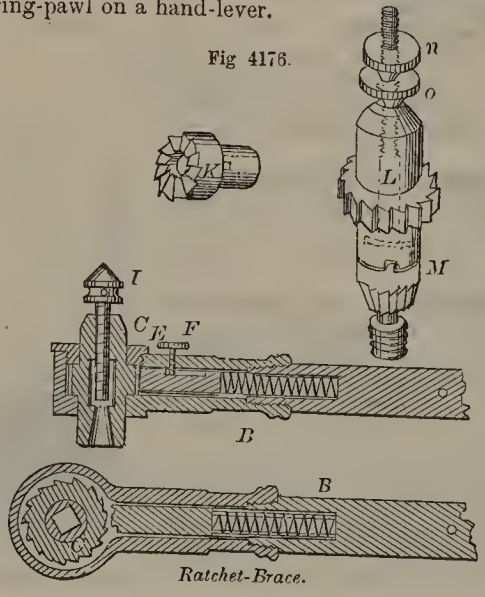
Fig. 4175.



Ratchet-Brace.

Ratch'et-brace. A boring-brace in which the spindle carrying the bit is rotated by means of a ratchet-wheel and a spring-pawl on a hand-lever.

Fig 4176.



Ratchet-Brace.

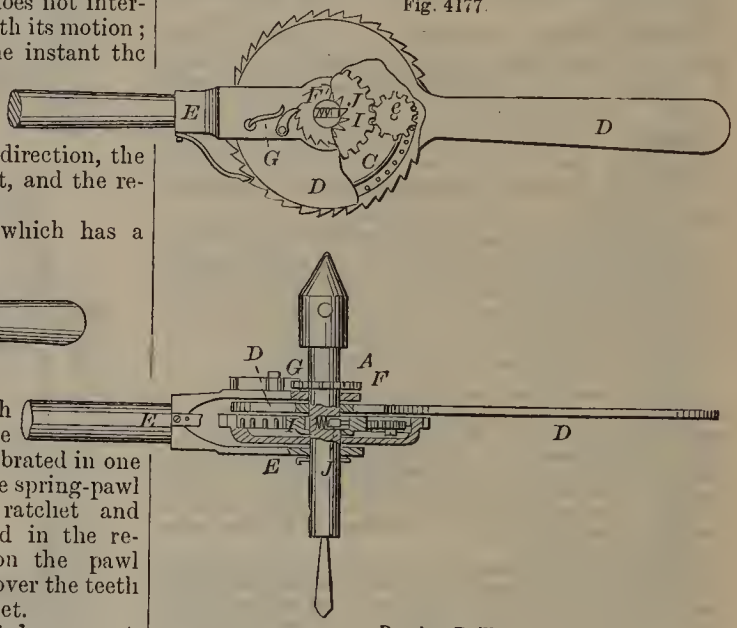
Fig. 4176 has two interchangeable shafts *C L* for drills and countersinks *M K*, fed respectively by thumbscrews *I o n*. Either is secured in place by the screw-cap *E*. The pawl is caused to engage the ratchet by pressure of a spring in the handle *B*, being prevented from falling out while one shaft is substituted for the other by a screw *F* entering a slot in the pawl.

Ratch'et-drill. A drill whose rotatory movement is derived from a ratchet and pawl actuated by a lever.

The movement is usually intermittent, the pawl engaging the teeth only when the lever is pushed in one direction, and slipping over them when drawn backward. In some, however, a continuous rotary motion is imparted to the drill.

Sinclair's (Fig. 4177) is of this kind. The spindle *A* has a ratcheted shoulder *F* which holds the forked handle *E E* and disk handle *D D* in place, and in which the pawl *G* engages when this handle is worked in one direction. When the movement is reversed a second spring-pawl on the handle *E* engages the teeth of the wheel *C*, which are inclined in a direction opposite to those on the disk *F*. Pins on this wheel engage the pinion *e*, which rotates the wheel *I*; during this movement a spring-bolt *J* in the drill-spindle enters between two teeth of the wheel *I*, slipping over them when the handle *E* is again pushed forward, so that the pawl *G* again engages with *F*. By this means a continuous movement in one direction is communicated to the drill-spindle.

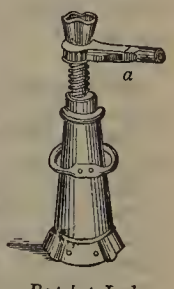
Fig. 4177.



Ratchet-Drill.

The handle *D* serves to hold the device firm. See also RATCHET-BRACE.

Fig. 4178.



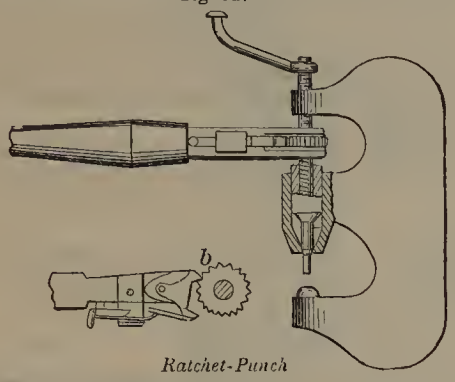
Ratchet-Jack.

Ratch'et-jack. A form of screw-jack. The rotatable lever-socket *a* has a collar encircling the head of the screw, and a pawl which drops into the notches of a ratchet fixed thereto, so that the operator may work the jack without moving from his place. See SCREW-JACK.

Ratch'et-punch. A punch operated by a screw, which is rotated by a lever having a pawl connection

to a ratchet *b* on the shank of the screw. The crank on the upper end of the screw-shank is for a quick

Fig. 4179.

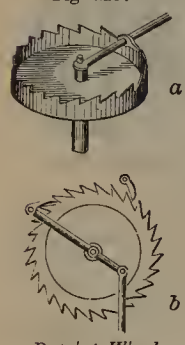


Ratchet-Punch

motion, to bring the punch down to its work or to raise it after the hole is made.

Ratch'et-wheel. A wheel having inclined teeth for receiving a ratchet or detent, by which motion is imparted or arrested.

Fig. 4180



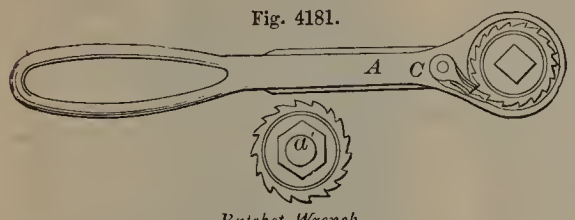
Ratchet-Wheel.

The teeth are of such shape as to revolve and pass the detent in one direction only. The detent may be a pallet, as at *a*, or a pawl, as at *b*. The former receives an intermittent rotation by a reciprocating circular movement of the arbor and its cam. The wheel in the second figure is intermittingly rotated by the motion of one pawl, while the other one acts as a detent in the intervals between the forward motions of the former.

Ratch'et-wrench. A wrench operated by a ratchet and pawl, so that it may be turned continuously without removal from the bolt or nut to which it is applied, by a backward and forward movement of the handle.

In Fig. 4181, the wrench-holder, turning in a cavity in the handle *A*, is removable, and its upper part has ratchet teeth, over which projects a lip on the pawl *C*. The nut fits into a cavity *a*, while

Fig. 4181.



Ratchet-Wrench.

the upwardly projecting portion of the bolt passes through the central aperture.

Rate. 1. (*Nautical.*) In the old classification of men-of-war in the British navy, ships were *rated* according to the number of guns which they carried. This has been much disturbed by the introduction of armored vessels, heavy ordnance, rams, etc.

Formerly the first rate was from 100 guns upward; the second rate was from 90 to 100 guns; the third rate was from 80 to 84 guns; the fourth rate was from 60 to 74 guns; the fifth rate was from 32 to 40 guns; the sixth rate included the smallest armaments.

In the United States navy vessels are rated according to their tonnage. Thus, ships of 3,000 tons and upward are first rates; 2,000 to 3,000 tons are second rates; 800 to 2,000, or iron-clads from 1,200 to 2,000, are third rates; under 800 tons, or iron-clads under 1,200, are fourth rates. These are farther subdivided into classes, according to their armament and tonnage.

2. (*Horology.*) The daily gain or loss of a chronometer or other timepiece in seconds and fractions of a second.

Răt'ing. The *retting* or *rotting* of flax, to loosen the fiber from the woody portion and gum; the *hare* from the *shives*. See RETTING.

Rat'line. (*Nautical.*) One of the ropes (from 1 inch to 1½ inch in circumference) forming the steps of the shrouds, whereby they are ascended.

Rat's-tail. 1. (*Nautical.*) The pointed or tapered end of a rope.

2. A tapered, round file.

Rat-tail File. A small, tapering file, circular in its transverse section.

Rat-tan'. (Malay, *rotan.*) The stem of a cane of the genus *Calamus*, especially used for making splints for chair seats and backs.

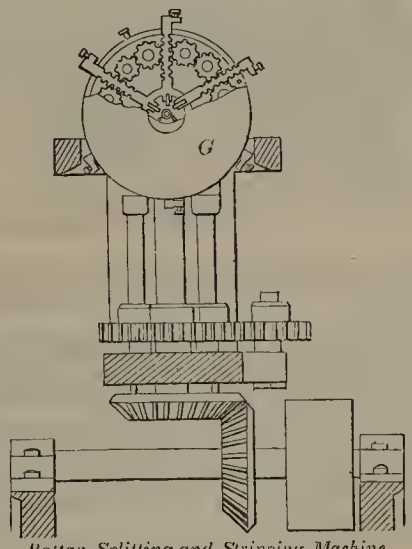
It abounds in Southern Asia in moist situations, and the various species are used for hanks for sails; cables, sometimes as much as 42 inches round; cords, withes, and walking-sticks; also for making splints for baskets and brooms, fish-weirs, hurdles, hoops, carriage-seats, and many other purposes. The larger varieties grow to a size of 3 inches diameter, and to a hight of nearly 100 feet. It is cylindrical, jointed, and destitute of branches.

Rat'tan-as. A coarse sacking made at the Mauritius.

Rat-tan'-ma-chin'er-y. The rattan used in this country is imported from Singapore, packed in bundles in lengths of 8 to 16 feet. It is sorted, preliminary to being prepared for its various uses, into 12 sizes, according to diameter, and washed in revolving boxes. The joints being scraped smooth by machinery, the hard outer surface is removed in strips, which are used for the bottoms of cane-seat chairs and similar latticed work, and the rounded pith portion, known as *reed*, is woven into baskets, tables, and chairs. The shavings are made into matting, the *rub* into mattresses.

After washing and scraping, the rattans are presented to the action of machines comprising a set of drawing or feeding rollers, and knives which make longitudinal incisions in the hard outer coating, dividing it into strips which are then separated from the inner porous or pithy portion by means of a tubular cutter, through which this part is drawn while the strips are thrown off by the conical exterior of the mouth of the cutter. Another machine then reduces the strips to an even thickness and width.

Fig. 4182.



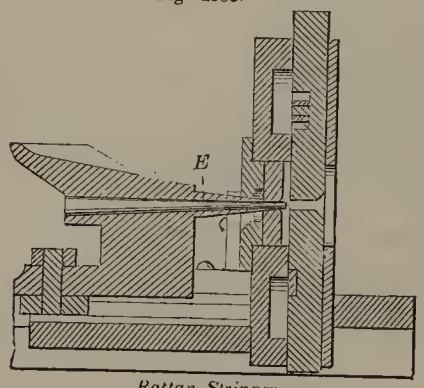
Rattan Splitting and Stripping Machine.

In the preparation of rattan for use, it gives occasion for the use of machines for straightening, washing, scraping the joints, slitting, stripping, dressing, or reducing, which is a planing and trimming operation, and polishing.

In one combined slitting and stripping machine a series of rotary cutters are pivoted in the end of rack-bars placed radially in the stock *G* and caused to simultaneously approach or recede from its center, so as to operate on the rattans as they are drawn through it by the feed-wheels. They are held to their work by springs, and accommodate themselves to the varying thickness of the rattan, which is then fed to a tubular cutter. Fig. 4182.

In Fig. 4183, the rattan, after being operated on

Fig. 4183.

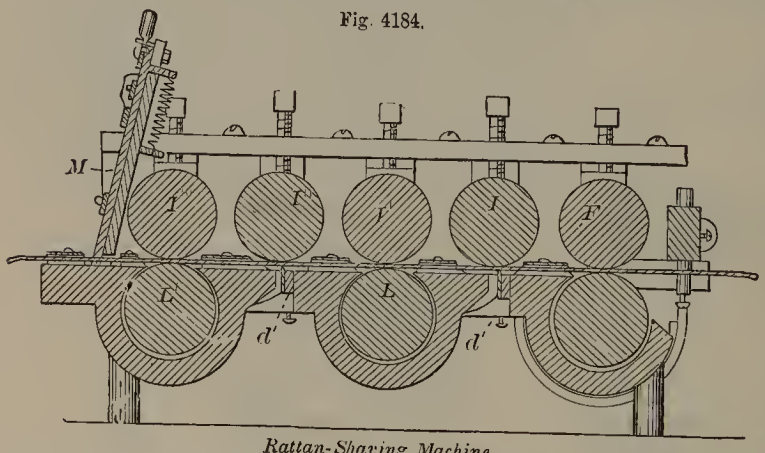


Rattan-Stripper.

by radial cutters, is presented to the tube or quill *E*, which may be adjusted at a variable distance from the cutters.

Machines for shaving off the joints and evening the strips are also used. In Fig. 4184, the first of these objects is effected by inclined knives *M*, and as the strip is drawn forward by the rolls *I''' I'' I' I L L'*, the pithy under-surface is removed by knives

Fig. 4184.



Rattan-Shaving Machine.

or scrapers *d d*, after which circular cutting-flanges on the roller *F* and its fellow trim the edges to an even width.

Sawyer employs a tubular cutter, having an opening of hexagonal or other polygonal section, surrounded by radial ribs or fins, by which the outer coat is split, and at the same time separated from the interior, which is drawn through the tube.

Advantages are claimed for the hexagonally sectional form of the pith as peculiarly adapting it for its destined purposes.

Watkins has patented a method of uniting the ends of the separated strips by scarfing, removing the smooth, glossy part from the ends of strips, and joining them by cement, so that they may be formed into continuous lengths.

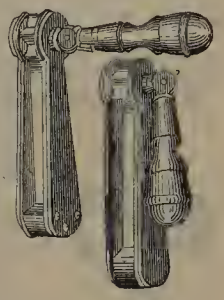
Also a process of saturating the pith when cut into strips, with a solution of shellac or other preparation, in order to harden it and render it adapted to purposes for which the outer surface only is usually employed.

After being split off, the exterior rind is bleached, constituting chair *cane*, and put up in bundles of 1,000 feet. One hundred of these bundles make a bale.

Rat-teen'. (*Fabric.*) A kind of woolen stuff.

Rat'tle. *a.* An instrument consisting of a vibrating tongue and a rotating ratchet-wheel by which a sharp, *rattling* sound is produced to make an alarm. Watchmen were formerly furnished with them to sound a rallying signal, and they were kept in private houses to enable the occupant to call the watch or sound a fire-alarm. See WATCHMAN'S ALARM.

Fig. 4185.



Policeman's Rattle.

b. A child's toy made in a similar way, or consisting of a case of wicker-work or other material and inclosing small pebbles or other objects which produce a rattling sound.

Rat'tler. (*Cutlery.*) A term applied by cutlers to a form of razor whose blade is ground very thin by laying it longitudinally on a stone and reducing the angle of the sides to about 15°. When the nick extends only a part of the way back, it is called a *half-rattler*.

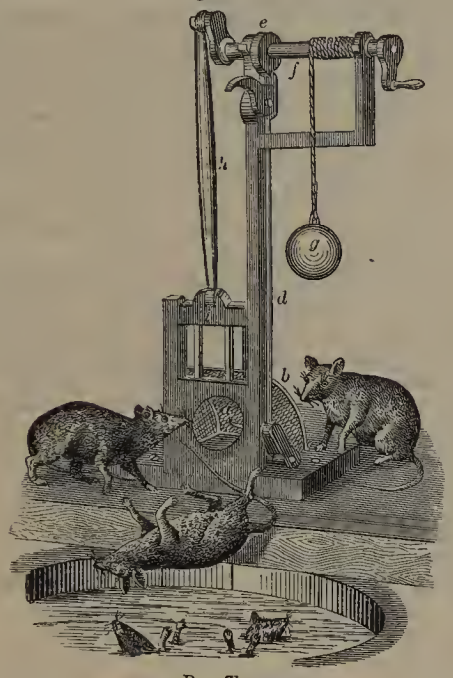
Rat-trap. A device for catching or killing rats and similar vermin.

The older were generally of two well-known forms, — a wire cage, having funnel-shaped entrances with pointed wires at the inner extremity, through which the animal, attracted by the bait, could enter, but which opposed an invincible obstacle to his egress; and a pair of spring-jaws, which were forcibly closed when he attempted to remove the bait placed on a hook between them. Of late years the inventive faculty has been considerably exercised upon devices of this class. Among these are embraced, — revolving spikes, actuated by a weight; a portcullis, which impales the animal; doors which fall and inclose him; contrivances which knock him into the trap, or give him a killing blow (the sockdologer); double doors, of which the outer one closes when the rat enters, and is caused to open again when he passes through the inner, where he is imprisoned; traps with swinging doors, closed by the passage of the animal through them; traps which are automatically reset after he is secured or killed; peculiarly arranged dead-falls; tilting-boards and traps, through which he falls, and which then resume their usual position; and others.

In Fig. 4186, the bait is placed on a hook within the aperture *a*; it is protected on the other three sides by a wire-guard *b*, and, when disturbed, the hook partially rotates the rock-shaft *c*, releasing a lug at top of the rod *d* from contact with the tooth of the snail *e*, permitting the shaft *f* to rotate under

the influence of the weight *g*, and through the medium of the pitman *h* causing the descent of the cross-head *i*, to whose under side are affixed two pins, which impale the animal when he meddles with the bait.

Fig. 4186.

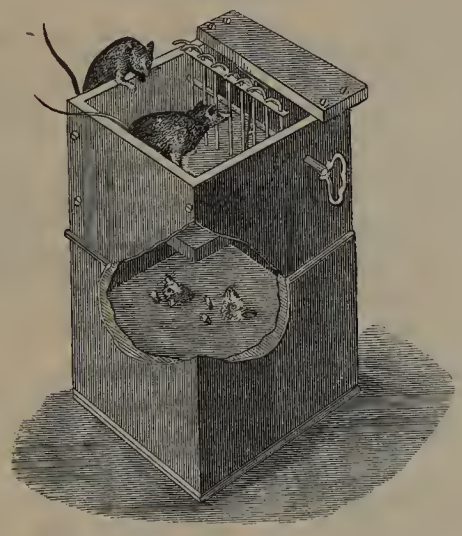


Rat-Trap.

The pins are disengaged from the animal's body and the trap reset by the onward movement of the shaft *f*, which continues its revolution until the snail *e* again engages the stop.

Fig. 4187 consists of a box having a hinged open top and a cistern below. The bait is protected by a wire guard having an opening in the middle large enough to admit the animal's muzzle. On seizing the bait a catch is released, allowing the pivoted platform to partially rotate by the animal's weight and

Fig. 4187.



Rat-Trap.

drop him in the cistern below, when the depressed end again rises and the catching device is re-engaged, holding the platform in position until displaced by another nibble. See also ANIMAL-TRAP.

Rave. (*Vehicle.*) One of the side pieces of a wagon-body frame or of a sleigh.

Rave-hook. (*Nautical.*) A hooked iron for clearing old oakum out of the seams.

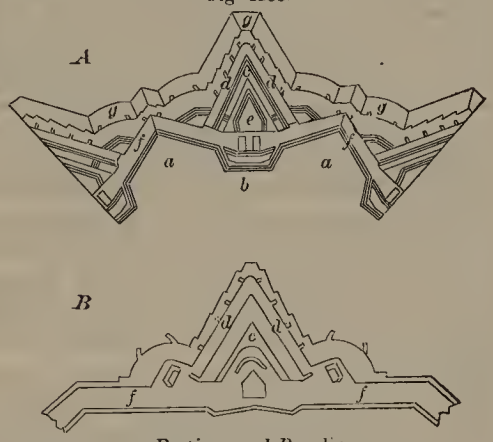
Rav'el. (*Weaving.*) A comb-like instrument between whose teeth the yarn-threads are passed when being distributed upon the beam of the loom. The *ravel* has a length equal to the width of the web, and maintains the order which the threads acquire in the *warping-mill*. A *separator*.

The ravel is also used in winding yarns from balls or hanks on to a *balloon*.

Rav'e-lin. (*Fortification.*) A detached work having a parapet and ditch forming a salient angle in front of the *curtain*. It is erected upon the *counterscarp*, and receives flank defense from the body of the place.

Inside the *ravelin* may be a *redoubt* and ditch; the *gorge* is unprotected, and the *ravelin* may be considered a *redan* upon the *counterscarp*.

Fig 4188.



Bastions and Ravelin.

In the figure: —

a a are the bastions of the main work.
b, Curtain.
c, Ravelin.
d d, Ditch of ravelin.
e, Redoubt of ravelin.
f f, Main ditch.
g g g, Glacis.

Rav'el-ing-en'gine. (*Paper-making.*) A machine for tearing rags for making into pulp for paper. A *teazing-cylinder*. See RAG-ENGINE.

Ra'vens-duck. (*Fabric.*) A quality of sail-cloth.

Raw-hide. The untanned skin of animals, such as the cow and buffalo; usually prepared by liming and scraping off the hair.

The hide is cut into a continuous strip, several of which are afterward twisted or plaited together to form a rope, which is immersed in a solution that tends to preserve and render it more pliable. Ropes of this material are preferred to chain, hemp, or manilla for tiller ropes, being stronger than the two latter, and not liable to break suddenly like the first.

A mode of making small belting from raw-hide by cutting into a continuous strip, stretching, and afterward treating with a preservative solution, was patented by a firm in Leeds, England.

Raw-silk. Reeled silk wound from the cocoons, several fibers forming one thread.

The cocoons are immersed in warm water to soften the natural gum on the filaments, and the ends of a number being gathered are wound as a single thread upon the reel. When the skein is dry, it is made into a hank. See SILK-REEL.

Ra-za'go. (*Fabric.*) Coarse tow-cloth of Spain.

Ra-zee'. (*Nautical.*) A vessel cut down to a less number of decks, as from a two-decker to a frigate. The opposite of one *raised-up*.

Ra'zor. A keen-edged cutting instrument employed for removing the hair of the beard and head.

The edge and the back of the blade are more or less curved, and lines drawn from each side of the back and meeting at the edge include an angle of about 18°. If made in one piece, the sides are slightly hollowed in grinding. The cutting part is, however, sometimes made much thinner, and of uniform taper from back to front, and inserted in a backing piece.

The blade is formed with a tang, which is fastened in the handle by a rivet. The handle has no back.

From distant ages the custom of shaving has descended to modern times, though in different times and nations the practice has varied, the sealp or the face, in whole or in part, being subjected to the operation.

The ancient Egyptians shaved the head and face regularly. The priests shaved all over every three days. They also bathed twice a day and twice each night. The wool of any animal was an abomination in the temple, and therefore they were scrupulously dressed in linen. So also were the Hebrew priests (see Ex. xxviii. 42; Lev. vi, 10). Cotton was not known in Egypt except as a euriosity from India.

Joseph shaved himself before being presented to Pharaoh, and from their long residence in Egypt the Israelites came to adopt certain practices of a religious or social character. Moses made regulations concerning shaving, and special observances are prescribed in the ceremonies in taking the vows of a Nazarite, and iu relatiou to the cleansing of lepers. This was about 1490 B. C. Samson was an unshaven man until he fell into bad company and lost virtue, strength, and sight. The comparison (Isaiah vii. 20) of the king of Assyria to a hired razor seems to infer the completeness of the operation he would perform upon the subject, and the comparison of the king to a traveling barber may have inferred contempt for the agent.

The shaven crown and braided cue of the Chinese were originally marks of subjection imposed by the Manchoo Tartars so late as A. D. 1627.

Perhaps it was only the present peculiar mode that originated in this way, as the Japanese follow the same practice, adopting, however, a different style of tonsure.

The Homeric heroes were bearded. The custom of letting the beard grow prevailed until the time of Alexander, when, according to Plutarch, in Lysander, and Athenæus, the Greeks began to shave, and continued to do so until the time of Justinian.

"And this custom of shaving the beard originated in the age of Alexander, as Chrysippus tells us in the fourth book of his 'Treatise on the Beautiful and on Pleasure.' And Diogenes, when he saw some one once whose chin was smooth, said, 'I am afraid you think you have great ground to accuse nature for having made you a man and not a woman.' And at Rhodes there is a law against shaving, but no one minds it. And at Byzantium there is a law against barbers being possessed of razors, but they shave none the less. So says the admirable Chrysippus." — ATHENÆUS.

"Ctesippus, the fine son of Chabrias,
Has ceased to shave himself three times a day.
A great man among women, not with men."
TIMOCLES: quoted iu the "Deipnosophists."

Ctesippus, the Brummel of his time, becamc a proverb: —

"And I, too, once was a young man, O woman,
Nor did I then five several times a day
Bathe, as I now do bathe; nor at that time
Had I a soft eloak, such as now I have,
Nor such perfumes as now; now, I will paint myself,
And pluck my hair, by Jove! Aye, I will be
Ctesippus; not a man; and in brief time
I too, like him, will eat up all the stones."
MENANDER.

Ctesippus had sold the stones of his father's tomb to obtain means for his luxury.

In 454 A. U C., Paulus Ticinus Mænas imported barbers into Rome from Sicily. They werc at first peripatetie, but afterward had shops, whieh became the lounges of the metropolis, as we find by the contemporary poets and satirists. Pliny says that Scipio Africanus was the first Roman who shaved daily.

As early as Hippocrates some surgical operatious were regarded as beneath the attention of physicians, and were relinquished to the barbers. The Council of Tours, in 1163, prohibited the clergy from performing bloody operations, and the barbers became the possessors of their practice. Barbers were incorporated with the surgeons of London by act of Henry VIII., but were deprived of this association early in the eighteenth century. In Holland and Germany the mixed practice still continues.

After many hirsute centuries shaving again became common under Louis XIII. and XIV. of France, each of whom ascended the throne in infancy, and thus made smooth chins fashionable.

During the reigns of Elizabeth of England, and Peter of Russia, laws were enacted to compel certain classes to shave. The people were disgusted.

In Spain and Portugal the whiskers became the great objects of attention, and the loss of honor was followed by the loss of whiskers. John de Castro, in the reign of Catharine, Queen of Portugal, pledged one of his whiskers to the merchants of Goa, as security for a loan of 1,000 piasters.

The whiskers belonging to the image of Confucius are supposed to be capable of imparting wisdom and manly beauty to any one who may wear them. Unfortuuately, decapitation is the reward of any oue who removes them from the image, so that their virtues are never tested.

Artificial hair was used by the Egyptians, Carthagenians, Greeks, and Romans. A splendid wig has been preserved in one of the Egyptian tombs, and is now in a European museum.

Wigs were again brought into use in France about 1629, and the practice spread throughout civilized Europe. Kings, courtiers, and the devotees of law, physic, and divinity were not full dressed without a wig. The absurd idea yet obtaius. Horsehair and goat's hair yet protect or parch the legal and judicial brain in the "*tight little island*." See HAIR, par. 6, page 1047.

Cortez found the Mexicans using razors of obsidian.

Pepys, in his Diary (May, 1662), recommends "trimming one's self with a pumice-stone, which I learnt of Mr. March, and I find it very easy, speedy, and pleasant."

Among the Knights of the Razor are to be found enrolled the great inventors Ctesibus, Arkwright, and the great English painter, Turner; the latter was a very humble member of this ancient and honorable fraternity, and was dropped from the rolls of the order at quite an early age. having shown a degree of genius for drawing which was perhaps deemed incompatible with his success in his hereditary profession.

The order of procedure in making the best razors is as follows: —

1. The blade is molded.
2. Forged.
3. Ground and *scorched* to take off the black scale.
4. Drilled for the joint, and stamped with the name.
5. Hardened and tempered.
6. Ground
7. The shoulders are ground on a dry stone.
8. The blade is ground on a leaden *lap*, which gives the true curve to the surface.
9. The tang and back are glazed by a leather glazer.
10. Polished on a buff-wheel with crocus.
11. Handled.
12. Set.

Razor-blades are forged from cast-steel (except the cast-iron ones); the bars being tilted to ½ inch in breadth, and a thickness equal to the back of the razor.

The blades are heated in a cokc or charcoal fire, and dipped into the water obliquely. In tempering, they are laid on their backs upon a clear fire, about half a dozen together, and they are removed, one at a time, when the edges, which are as yet thick, come down to a pale straw color. Should the backs accidentally become heated beyond a straw color, the blades are cooled in water, but not otherwise.

Holtzapffel agrees with Stodart, that the best cooling mixture is water at 40° Fah.

Shavings of leather, added to the fire, are said to prevent the eracking of the razor when plunged into water.

After tempering, they are ground on a stone of 5 or 6 inches diameter for the finer, or from 12 to 15 inches diameter for the coarser, kinds, and afterward on a lap charged with fine emery in oil; two *courses*, the last with finer emery than the first, being employed.

The final polishing is effected on a soft leather wheel charged with crocus, both the wheel and razor being heated.

As the glazing and polishing wheels revolve away from the edge, a wire edge is left, which is *struck off* by tilting it up and sweeping it, edge foremost, over the face of a hone. Should the wire edge still remain, it is drawn perpendicularly over a strip of horn, and the sweeping operation repeated.

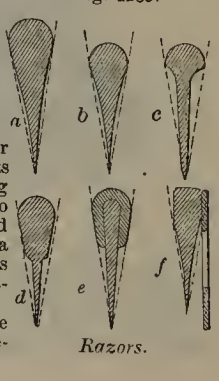
It is then honed, being laid flat on the side for this purpose. The manner of rubbing the edge against the stone varies among different operators, some preferring a long and sweeping and others a zigzag motion, while others again employ short circular or elliptic strokes; all, however, agree in working from heel to point. Should the wire edge arise during this process, it must be rubbed off on the horn as before. The work is then finished on the strop.

The keenness of its edge may be tested by drawing it obliquely across the thick skin of the palm of the hand, but the cutler also tries it upon the finger-nail, holding it at right angles to the nail and slightly drawing it, by which means a very slight notch or inequality may be detected.

When viewed with a magnifying power of 50 to 100, the edge of a razor exhibits a series of faint undulations, resembling ripple-marks. These, however, offer no impediment to its cutting properties, and unless imperfections are visible when a power of 20 to 30 linear measurement is used, the razor will generally prove satisfactory.

The hollowed form is imparted to the side to reduce the quantity of metal re-

Fig. 4189.



Razors.

quired to be removed in sharpening. *a b* show the most ordinary forms; each is ground transversely, the former on a wheel of 12, and the latter on one of 4 inches diameter.

In some cases, as *c*, the blade is ground longitudinally, giving it a thinner edge; these are termed *rattlers* by the Sheffield cutlers in consequence of their tendency to vibrate when shaving a heavy beard. Others (*d*) are ground in both ways. These are called *half-rattlers*. *e* is formed by setting the blade in a backing. *f* has a brass frame or guard to prevent persons whose hands are tremulous from accidentally cutting themselves. It is called a guard-razor.

Ra'zor-pa'per. Smooth, unsized paper, one side of which is treated with a composition of crocus and flour-emery in powder. It is used to wipe the razor, and is intended as a substitute for the strop.

Ra'zor-strop. An implement for sharpening razors or other thin-edged tools. It usually has a handle and a case for receiving it when not in use. Some kinds have but two abrading surfaces, — that to which the razor is first applied, consisting of leather thinly coated with fine emery-powder; and the second, by which keenness of edge is finally imparted, of leather alone. Others have four sides, coated respectively with a hard composition and with leather of different degrees of fineness, to which the razor is successively applied.

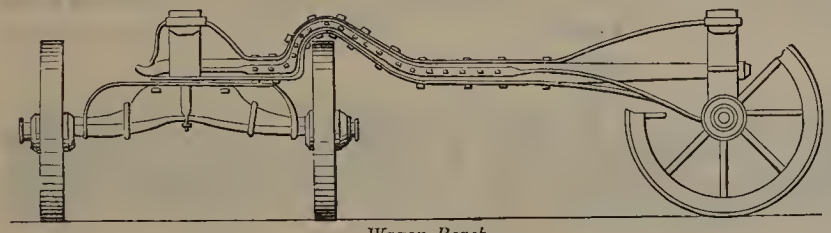
Barbers keep their razors in order after being once *set* by rubbing on a leathern strap suspended by one end, and held by the other.

Reach. 1. (*Vehicle.*) A pole connecting the rear axle to the *bolster* of a road-wagon. A *coupling-pole.*

Some modern carriages have none, the *bed* or body performing that duty.

A reach for a certain description of city wagon is shown in Fig. 4190. It is arched in front, so that

Fig. 4190.



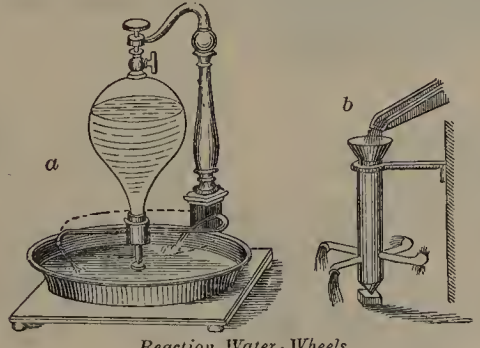
Wagon-Reach.

the fore-wheels may pass under it, enabling the vehicle to be turned in a shorter space. The circular sway-bar is extended, so as to support the reach when turned in any position.

2. (*Hydraulic Engineering.*) That portion of a canal between two locks having a uniform level. Also called a *pond*. *Locks*, *lifts*, *inclines*, *slides*, or *sluices* connect *reaches* of different levels.

Re-ac'tion Wa'ter-wheel. A wheel to which a rotary motion is imparted by the action of streams of water issuing tangentially from its sides under the pressure of a head of water entering it from above. The principle, which is that of recoil, is embodied in *Barker's mill* and in the turbine. It differs in nothing from Hero's Æolipile, except that in the latter steam under pressure is the motor. Reaction water-wheels are made single or double, the latter having two on a single shaft. One form has radial buckets on which the water confined in a vertical chute impinges (see FLUTTER-WHEEL) and then escapes at the ends through wheels on the reaction principle. This form has a horizontal axis. See also TURBINE.

Fig. 4191.



Reaction Water-Wheels.

The motive power exerted by liquids escaping horizontally is illustrated by a device called the hydraulic tourniquet (Fig. 4191), consisting of a vessel pivoted at its upper and lower extremities and having two pipes at bottom whose ends are bent in opposite directions. On filling the vessel with water, it escapes through these tubes, causing the vessel to revolve on its axis.

Perley and Pattee's saw-mill, at the Chaudière Falls, Ottawa River, Canada, has 6 gang-saws, each driven by a Rowe reaction-wheel, 5 feet in diameter, 400 inches sectional area of discharge. The head is 14 feet, and the power of each is about 70 horses.

Read'ing-glass. A large magnifying lens, used to assist in reading, etc.

Read'y Reck'on-er. A table or an instrument for making simple calculations, as the amount of wages due a workman for a given time, etc.

Re'al Ra'di-us. (*Gearing.*) The radius of the circle touching the crests of the teeth of a cog-wheel. The radius of the *pitch-circle* is called the *geometrical radius.*

Ream. A quantity of paper of any size containing 20 quires or 480 sheets. A common practice is now to count 500 sheets to the ream.

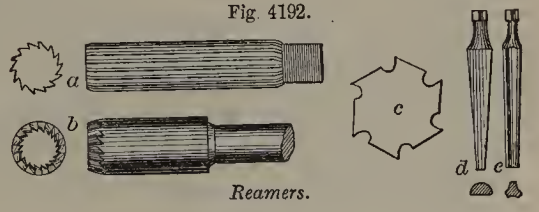
Ream'er. Sometimes, but incorrectly, written *rimmer.* A tool used to enlarge a hole and bring it to a shape the counterpart of the tool, whether cylindrical or tapering.

Broaches are *reamers*, being multiple-sided taper rods, whose angles cut the sides of the holes in which they are rotated. See BROACH.

The reamer is used in *truing* or rounding the holes made by a rock-drill.

As a machinist's tool (*a b*), it is fluted and slightly

Fig. 4192.



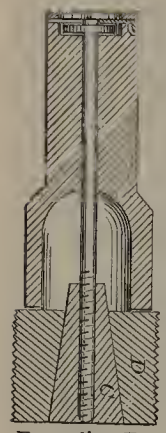
Reamers.

tapering; the blades being worked out of the solid metal by planing or milling on a machine. The flutes are then *backed off* like a *tap* to give a saliency to the cutting-edge.

Instead of mere longitudinal fluting, the grooves in the tool may be made spiral, a right and a left hand, crossing obliquely so as to leave the surface in diamond-shaped portions. The flutings are then planed out and backed off, the result being a toothed reamer *c* of effective character.

The flat-sided reamers, such as *d e*, triangles, squares, and pentagons, are properly termed *broaches.*

Fig. 4193.



Expanding Tap and Reamer.

Tools to be driven through a hole are DRIFTS (which see).

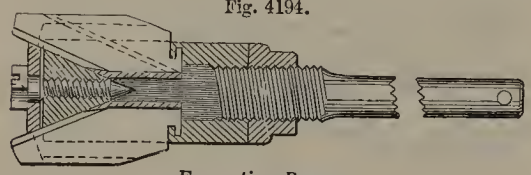
Half-round reamers are used in braces to enlarge holes in sheet-metal or small castings.

A revolving tool which cuts one size as it goes is a *drill*. A *reamer* is a cutting tool for enlarging a hole, and should enter the hole a piece before it begins to cut, so as to work steadily and straightly. This is not descriptive of the action of a drill, even though employed to enlarge an opening, as the *cored-out* hole in a casting.

In Fig. 4193, the cutters *D* are made in sections, having dovetail projections fitting grooves in the conical plug *C*, which is drawn upwardly so as to expand the tool radially to cut a dovetailed or undercut recess.

In Fig. 4194, the cutters are moved longitudinally by connection with a nut on the shank, and are

Fig. 4194.



Expanding Reamer.

driven outward in their guide-slots by the conical end of the shank.

Ream'ing-bit. A broach of hardened steel having a taper form and angular cutting-edges. See BIT.

Fig. 4195.

Reaming-Bit.

Fig. 4195 has a guide at the end of the reamer to fit the hold to be enlarged and maintain the reamer in central position.

It is used for boring out truly or enlarging a hole commenced by a bit of ordinary construction. It has usually a shank about as large as the hole made by its cutting-face, to insure the straightness of the hole. Frequently, it has cutting-edges on its cylindrical portion, and acts to dress off irregularities and make a perfectly cylindrical opening.

Reaming-bits are used in drilling metal; also in dressing to roundness and enlarging the size of holes bored by rock-drills. See REAMER.

Ream'ing-i'ron. (*Calking.*) A blunt chisel used for opening the seams between the planking of a ship preparatory to calking them with oakum.

Reap'er. A machine for cutting grain in the field. Wheat and barley were commonly cultivated in ancient Egypt. The former was cut in five months after sowing, the latter in four. The wheat was bearded, and generally cut below the ear, as in the annexed figure. It was cut with a smooth-edged or a toothed sickle. Both are represented in the tombs, and illustrations are given in this work under the caption SICKLE.

The whole series of harvesting and thrashing operations are shown in the accompanying illustration, which is from a tomb at Thebes of the probable date of 1490 B. C. The condition of the standing wheat

Fig. 4196.

Harvest Scene (Thebes, 1490 B. C.).

shows that it was cut below the ear. Two men are working together, and, according to the then usual mode of representing such things, the motions of the parties are exactly simultaneous. The next man is taking a drink, sickle over his shoulder, in a manner quite customary among us, at this distance of thirty-three centuries. The man behind him is probably a gleaner, and urges him to hurry, as he too wants a drink. Next is shown a gleaner with his basket slung upon his back. He picks up the scattering ears and jerks them into his basket, like the chiffonier of Paris with his rags. We next see two men with a rope basket, carrying the ears from the field to the heap where they are tramped by cattle; a man tending with a whip and another throwing in the ears with a three-pronged fork. Then comes the winnowing; men with scoops lift the grain and chaff, throwing them up in the air, that the wind may blow away the chaff. By this time all parties are dry, and here is a kid-skin bottle hanging in the tree and a dusty Copt taking a pull at it. The next scene is at the grain-heap, where two scribes keep tally, — one, of the amount brought from the winnowing-floor, and the other of the amount sent to the granary.

Another harvest scene from the tombs is worth noticing in this connection, though the part selected is more specific in the refreshment line than in the work performed. In Egypt, as with us, the cool drink at the end of the row was not the least pleasant part of the day's experiences, but they could not rest in the shady fence-corner for lack of the trees and the fences. In the drawing, one tree lends its welcome shade, and to a limb is hung the kid-skin bottle at which the "fellah" is sucking. On the stand are two jars waited on by another "fellah" with a flabella, — call it a fly-brush. A thirsty man is devoting himself to a bottle, and a female comes up with a fresh supply. Another reaper, sickle on

Fig 4197.

Harvest Scene (Time of Moses).

his shoulder, has a cup, and a poor, naked gleaner with his baskets puts in a claim for a drink.

While, as has been stated, it was common to reap the standing grain just below the ears, we also find two other modes, and they were also practiced in Gaul in the time of Pliny, 1,500 years afterward. One was to cut low and bind in sheaves, and the other to pull up by the roots. The figures represent these two scenes. The last-mentioned mode

Fig. 4198.

Binding and pulling Grain in the Egypt of the Pharaohs.

was practiced with the millet, doura, or whatever it was, — Wilkinson says *sorghum*. This was pulled, bound in sheaves, and carried to a place where the grain was stripped from the stalk by a man who drew it, a bunch at a time, over a comb or hackle. The operation is illustrated in a tomb at Eilethyas. The same instrument is now used for removing the capsules and seed from the flax-plant. It is called a *ripple*. See RIPPLE.

This *stripper* is probably like the *paddle-fork* mentioned by Pliny.

The references in the Bible to reaping and to the sickle wherewith it was cut are frequent, but add nothing to the perspicuity of the Egyptian paintings.

Coming down to early classic periods, so called, we find that the Greeks added nothing and the Romans little to the crude old mode of cutting grain by the curved sickle of Egypt.

Varro describes three modes of reaping as common in Italy: —

1. Cut low by a hook, the ears being afterward cut off and sent in baskets to the granary.
2. Cut off below the head by a toothed sickle, and the heads carried off in baskets.
3. Cut off at half the length of the straw.

In the first century of the Christian era we hear from Gaul. Says Pliny (A. D. 70): —

"The mode of getting in the harvest varies considerably. In the vast domains of the provinces of Gaul, a large hollow frame, armed with teeth and supported on two wheels, is driven through the standing grain, the beasts being yoked behind it (*in contrarium juncto*); the result being that the ears are torn off and fall within the frame. In other countries the stalks are cut with the sickle in the middle, and the ears are separated by means of paddle-forks."

The accompanying cut is a good restoration of the Gallic harvester of Pliny's day. Palladius wrote the *De re rustica* in the fourth century A. D., and gives a good description of this contrivance, which was similar to our "heading-machines," having a row of sharp teeth at the front edge, between which the straw passed, the head being torn off at the angle where the teeth met, and falling into the box of the machine.

The description of Palladius is as follows: —

"In the plains of Gaul, they use this quick way of reaping, and without reapers cut large fields with an ox in one day. For this purpose a machine is made, carried upon two wheels; the square surface has boards erected at the side, which, sloping outward, make a wider space above; the board on the fore part is lower than the others; upon it there are a great many small teeth, wide set in a row, answering to the hight of the ears of the corn, and turned upward at the ends; on the back part of this machine two short shafts are fixed, like the poles of a litter; to these an ox is yoked, with his head to the machine, and the yoke and traces likewise turned the contrary way: he is well trained, and does not go faster than he is driven. When this machine is pushed through the standing corn, all the ears are comprehended by the teeth, and heaped up in the hollow part of it, being cut off from the straw, which is left behind; the driver setting it higher or lower, as he finds it necessary; and thus, by a few goings and returnings, the whole field is reaped. This machine does very well in plain and smooth fields, and in places where there is no necessity for feeding with straw."

After the lapse of fourteen centuries this machine has been reinvented, and is now used as a *header* for gathering clover-seed. See Figs. 1346, 2465.

The separation of the ears from the grain in the sheaf, mentioned above as being performed by paddle-forks, was probably done by drawing the bunches of grain over a paddle whose end

Fig. 4199.

Reaper in Gaul (A. D. 70).

was deeply notched and the teeth sharpened. The motion would be something like that of hackling hemp, and the ears would be speedily removed by this means. The object in saving the wheat, etc., in the head instead of in the sheaf, was probably to economize mow room. When stored in the ear instead of being first thrashed, it was as a precaution against weevil. Some have interpreted the passage of Pliny to refer to a comb of similar character, which caught the ears of the standing grain and tore them off or held them while they were beaten off by a paddle. This reminds one of the still simpler plan of the Northern Indians of Minnesota and Canada, who collect their store

of wild rice by leaning the heads over the side of the canoe and beating out the grain.

The above plans of heading the grain leave the straw in the field, which is a merit or otherwise, according to the circumstances of the case, — location, market, and mode of farming.

It would be absurd to overlook the different circumstances of Minnesota and Middlesex, which determine the question of economy. Pliny well says: —

"The diversity of the methods employed in harvesting mainly depends upon the extent of the crops and the price of labor."

The modern era of reaping-machines commences with the latter portion of the last century. The names of those who made the earliest attempts should be preserved, for in this, as in almost all similar cases, it was after a succession of earnest attempts by different parties that the desired success was achieved. Each great invention that has blessed us in modern times has been fought over. Witness steam-engines, steam navigation, photography, reaping-machines, and the electric telegraph. Most of those who worked at these problems added somewhat to the eventual success, and we may surely consider the matter with amiability and try to avoid acrimony.

The first modern machine resembled the old Gallic implement, in the respect that it stripped the head from the straw. The English machine of Pitt, in 1786, had a cylinder on which were rows of *combs* or *ripples*, which tore off the ears and discharged them into the box of the machine. For about two-score years attention was principally directed to revolving cutters or systems of revolving blades.

The motion of the cutting apparatus being derived from the rotary motion of the wheels supporting the implement, it naturally occurred to connect the axle or wheel with a rotary cutter, and later with an oscillating one, which had its analogues in the swing of the scythe and the reach of the sickle. A few attempts were made at a reciprocating knife, but they were scarcely heeded, and probably never made. The first reciprocating knife was in 1822.

As to the mode of attaching the horses, it was almost universally deemed necessary to hitch them behind the implement, which they pushed before them. Up to 1823 but four inventors hitched the team in front of the implement: one was in 1806; the others in 1820, 1822, 1823.

As soon as this idea did occur to the inventors, they made the horse walk alongside the swath, cut by the knives, constituting what is known as the *side cut*.

1799. Boyce had a vertical shaft with *six rotating scythes* beneath the frame of the implement. This was the first patented reaper.

1800. Meares tried to adopt *shears*.

1805. Plucknett introduced a *horizontal rotating circular blade*. He had a score of followers, and the first machine used in this country, and patented by Bailey (Fig. 4200) in 1822, was of this character. Two machines by Smith, of Deanstone, in England, in 1811, and Scott, of Ormiston, in 1815, were made on this principle, were used practically, and had considerable local celebrity. Smith's machine was illustrated in "Hall's Dictionary," in 3 vols., folio, 1811.

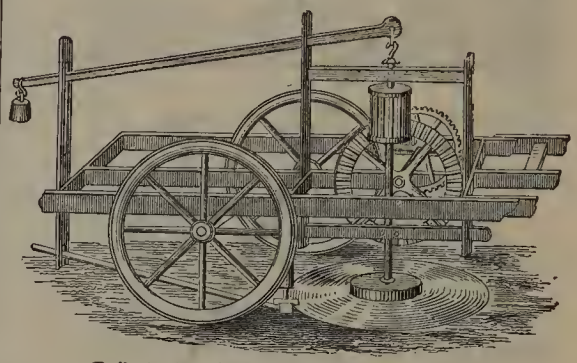
1806. Gladstone patented his *front-draft*, *side-cut*, revolving-knife machine. A segment *bar with fingers* gathered the grain and held the straw while the knife cut it, the fingers having the function of shear-blades. The forward draft was also adopted by Mann in 1820, and by Ogle, 1822, in his reciprocating cutter-bar machine

1807. Salmon had a machine with some new features, — a row of *vibrating knives* over *stationary blades; fingers* to gather the grain to the cutters; a *rake*, suspended and reciprocating sideways to carry the grain off to the side. The machine was pushed ahead of the horse, or was propelled by hand. The machine of Bell, 1826, which was brought forward to confound the American exhibitors in 1851, has the same kind of cutters, and was also propelled.

1820. Mann had revolving rakes on a vertical axis, to sweep the standing grain past the cutter, and deliver it in a swath

1822. Ogle shows the first *reciprocating knife-bar*. It is the type of the successful machines, but was constructed so poorly that its merits never became apparent. It was drawn by horses in *advance;* the cutter-bar *projected at the side*, and it had a *reel* to gather the grain to the cutter. The machine had a *grain-platform*, which was tilted to drop the gavel. The *first dropper*.

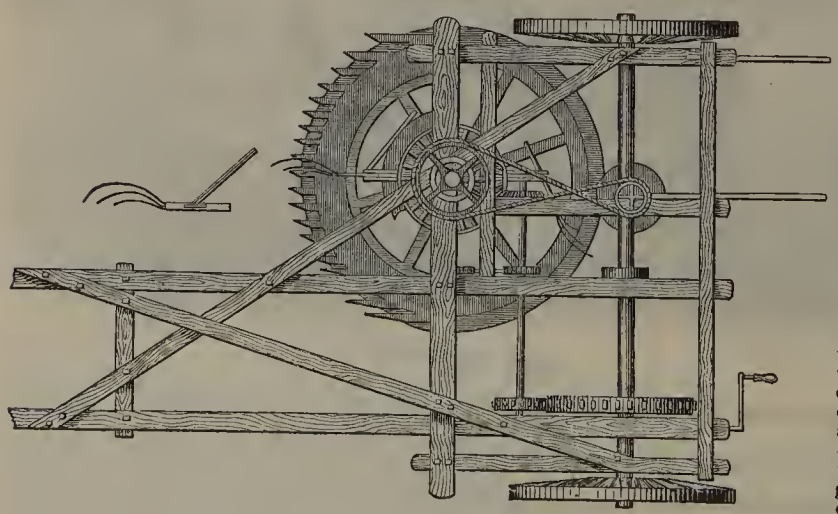
Fig. 4201.



Bailey's American Mowing-Machine (1822).

The machines previously mentioned are British. Fig. 4201 represents a self-sharpening mowing-machine, the first patented in the United States, in 1822. It has a circular revolving scythe on a vertical axis, rotated by gearing from main axle. The edge of the scythe in its revolutions passes under a whetstone fixed on an axis, and revolving with the scythe. The horse is in shafts, and *walks* in front of the left side of the machine, and always on the mowed ground after the first swath is cut. The grass, as it is cut, is first thrown by the progressive motion against a rise in the scythe-frame toward the center, and by the same motion is afterward thrown off in a regular row, following the center of the machine.

Fig. 4200.



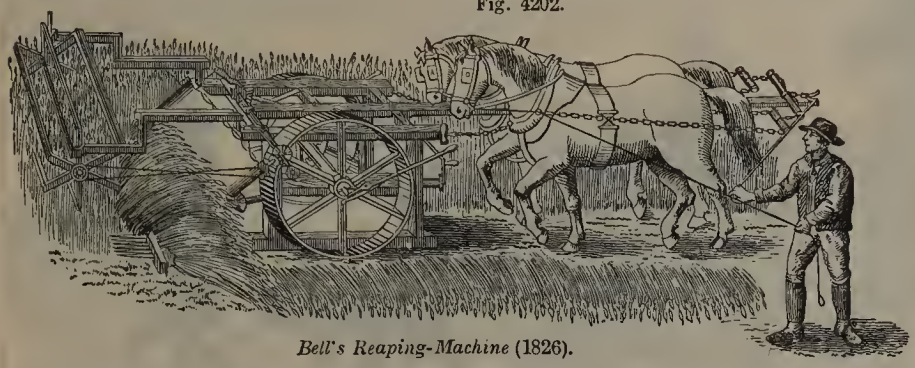
Gladstone's Reaping-Machine (1806).

The machine of the Rev. Patrick Bell was tried at Powrie County, Forfar, Scotland, in 1828. It cut a swath of five feet with the power of a single horse, about an acre an hour. It was used again in 1829, and occasionally for a few years succeeding, then slept till 1851, when the World's Fair of 1851 in London introduced the American machines to the British public. The old Scotch machine was then brought from its limbo to challenge the American stranger.

The machine had a square frame on two wheels, which ran loose on the axle, except when clutched thereto to give motion to the cutters. The cutter-bar had fixed triangular cutters, between each of which was a movable vibrating cutter, which made a shear cut against the edges of the stationary cutter on each side. It had a reel with twelve vanes to press the grain toward the cutters, and cause it to fall upon a traveling apron which carried away the cut grain and deposited it at the side of the machine. The reel was driven by bevel-gearing.

The following machines are American: —

Fig. 4202.



Bell's Reaping-Machine (1826).

1825. Ten Eyk had a horizontal cylinder, with spiral knives cutting against straight edges. The same was shown by Budding in 1830.

1828. Samuel Lane, of Maine, combined the reaper and thrasher.

1831. Manning had a row of fingers and a reciprocating-knife. It was pushed in front of the horse.

1833. Schnebly had a horizontal endless apron traveling intermittingly, and delivering its gavel at the side.

1833. Hussey, of Maryland, made the first valuable harvester. It was patented as a mower. It had *open fingers*, the knife consisting of triangular sections reciprocating in the space, cutting shearwise against the guards. It was *front draft*, *side cut*, and had a platform The open-top slotted finger was patented by Hussey in 1847. The cutter-bar was on a hinged frame. The raker rode on the machine

1834. McCormick, of Virginia, patented his reaper, which, with various improvements, in 1845 and 1847 received a Council medal at the London World's Fair in 1851. This machine had a sickle-edged sectional knife, reciprocated by crank and pitman by gear connection to the drive-wheel, on which the frame rested. Spear-shaped fingers gathered the grain, which was laid over to the cutter by a revolving-reel. A *divider* was used on each end of the platform The driver and raker had seats on the machine. The gearing and crank were placed forward of the driving-wheel.

1835. Randall had a *pair of knife-bars* reciprocating past each other. Wray, 1852, had the same

1836 Briggs and Carpenter combined the reaper and thrasher. Moore and Haskell, the same year. Ridley, in Australia, seven years afterward, did the same, and supposed himself to be the first inventor.

Hazard Knowles, the machinist of the Washington Patent Office, invented in 1837 a reaping-machine having a scalloped reciprocating cutter; the cutting apparatus jointed to a double arm, the opposite end of which was in turn jointed to the main frame, coincident with the axis of the crank-shaft; both supporting-wheels were drivers for the cutters. It was a front-cut machine, and had a lever to raise the cutting-bar to clear stumps and other obstructions. A machine was constructed in 1838, and in 1839 was purchased by Joel Lupton, who rode upon the machine along the turnpike to his home, near Winchester, Va. The machine was used occasionally during a few of the following years, but was soon laid aside, owing to a fear of the neighbors that it would disturb the relations of labor. It was afterward purchased by one of the large firms of reaping-machine makers, who became involved in the tedious and expensive litigation which ensued when the reaper became an important article of manufacture and trade. This machine is principally curious in its anticipation of so many of the important features of the more useful machines. Like Bell's machine in its history, though far superior to the Scotch machine in mechanical structure and adaptedness, it was a conception embodied in a single machine, and became an abandoned experiment, to be brought forward when the inventions and contests of others gave it an importance It was a machine of great possibilities, but its inventor failed to assert his rights. His position in the Patent Office prevented his becoming a patentee, and he preferred to retain his salary to embarking in the business of making machines of so novel a character About 1863 the machine was brought forward in a patent suit. It may be presumed that it formed but another instance of the rule, that a single machine made and practically hidden away shall not be allowed to defeat a patent when a subsequent inventor has showed due diligence. It also indicates that the patent is a *quid pro quo*, an exclusive right in return for an invention adequately described on record.

1838. Wheeler had a machine with a revolving endless apron to deposit grain in a box with a sliding bottom, by which it was deposited in gavels. A *dropper*.

1840. Lamb A platform to receive the gavels and carry the *binder*. The first hand-hinder.

1841. Churchill thrashed out the grain, the heads of grain being pushed into the thrasher-cylinder.

1842. Reed discharged the grain from the bed by rake-fingers projecting through slots in platform.

1846. Cook had a pendulous *rake swinging backwardly*.

1847. Ketchum had an endless chain cutter or *belt of knives*.

1847. Hussey's *slotted finger, open at top; knife of triangular sections*.

1848. Pease had a *grain-rake traveling sideways* beneath the platform, with slots for the fingers. Mann the same next year.

1848. Goble and Stuart had a revolving rake passing horizontally across the platform.

1849. Haines suspended the frame carrying the conveyor, reel, and cutter to the axles of the bearing-wheels, and hinged the frame to the tongue, so that it was capable of turning upon its bearings by means of a lever, to elevate and depress the cutter.

In 1849, Jonathan Haines, of Illinois, invented the "header," which is the principal machine on the Pacific coast.

1849. Purviance made the platform removable, to convert the reaper into a mower.

1849. Platt's self-acting *rake sweeping over quadrantal platform*. Same feature in Palmer and Williams's and in Seymour's, 1851.

1850. Adkins's cutter-bar on *hinged frame*.

1850. Knowles and Bevington's side *dropper*.

1850. Heath's *binder*, with a reciprocating rake beneath the platform.

1851. Watson's automatic *binder*.

1851. Miller's *backwardly reciprocating rake*.

1851. Allen geared the operative parts from both wheels, to distribute the driving-power.

1852. Atkins had a rake rigged on a vertical post. It had a jointed arm which swept across the curved platform and gathered the gavel against a shield; the post, rake, and shield then turned 90° on an axis, the rake was raised, and the gavel dropped in rear of the driving apparatus.

This list is but a commencement, but brings us to a period when things became lively in this line. Since this period nearly 3,000 patents have been granted in the United States for harvesters and attachments therefor.

In the summer of 1855, at a competitive trial of reapers about 40 miles from Paris, France, three machines were exhibited, from America, England, and Algiers. The following was the result in a field of oats: —

The American machine cut an acre in.....22 minutes.
The English machine cut an acre in .....66 minutes.
The Algerian machine cut an acre in.....72 minutes.

In 1855, Jonathan Haines patented a machine in which the finger-bar extended across the rear end of the main frame, and was connected at each side with the front end of said frame by rods jointed at one end to the frame, and at the other to the finger-bar. The inner of these rods was a drag-bar to advance the cutting apparatus The outer was a brace to maintain its position at right angles to the line of advance. It was supported laterally by a brace jointed at one end to the end of the finger-bar, and at the other end to the main frame at or near the axis of the crank-shaft.

In the Ball machine, shortly afterward, the drag-bar was joined rigidly to the finger-bar, and thus united drag-bar and brace in itself. The lateral brace was the same.

1856. The combined rake and reel of the "Dorsey" machine sweeping in a general horizontal direction across the quadrantal platform.

1857. Crook introduced an arrangement of driving-gears of unequal size to be used separately for changing the rapidity of vibration of the cutters.

1860. The Henderson rake, or what is known as the "Wood" machine, having a chain below the platform which carries the rake in a curved path.

1861. The Sieberling "dropper," which is a slatted platform that vibrates to discharge the gavel.

1861. Dutton inclosed the gearing in a metallic case, forming a part of the main frame.

Plate XLVI. shows three forms of the Whiteley "Champion" harvester of Springfield, Ohio. The upper figure is the mowing-machine; below it is the reaping-machine, with *dropping* arrangement, which deposits the gavel behind the cutter-bar; the lower figure is the self-raking reaper.

The reaping and automatic binding-machine of S. D. Locke, of Hoosick Falls, N. Y., made by Walter A. Wood of that place, and shown in Plate LI., is believed to have overcome the difficulties of the

PLATE XLVI.

THE "CHAMPION" HARVESTER.

As a Mower: a Dropper: a Self-Raker.

See page 1893.

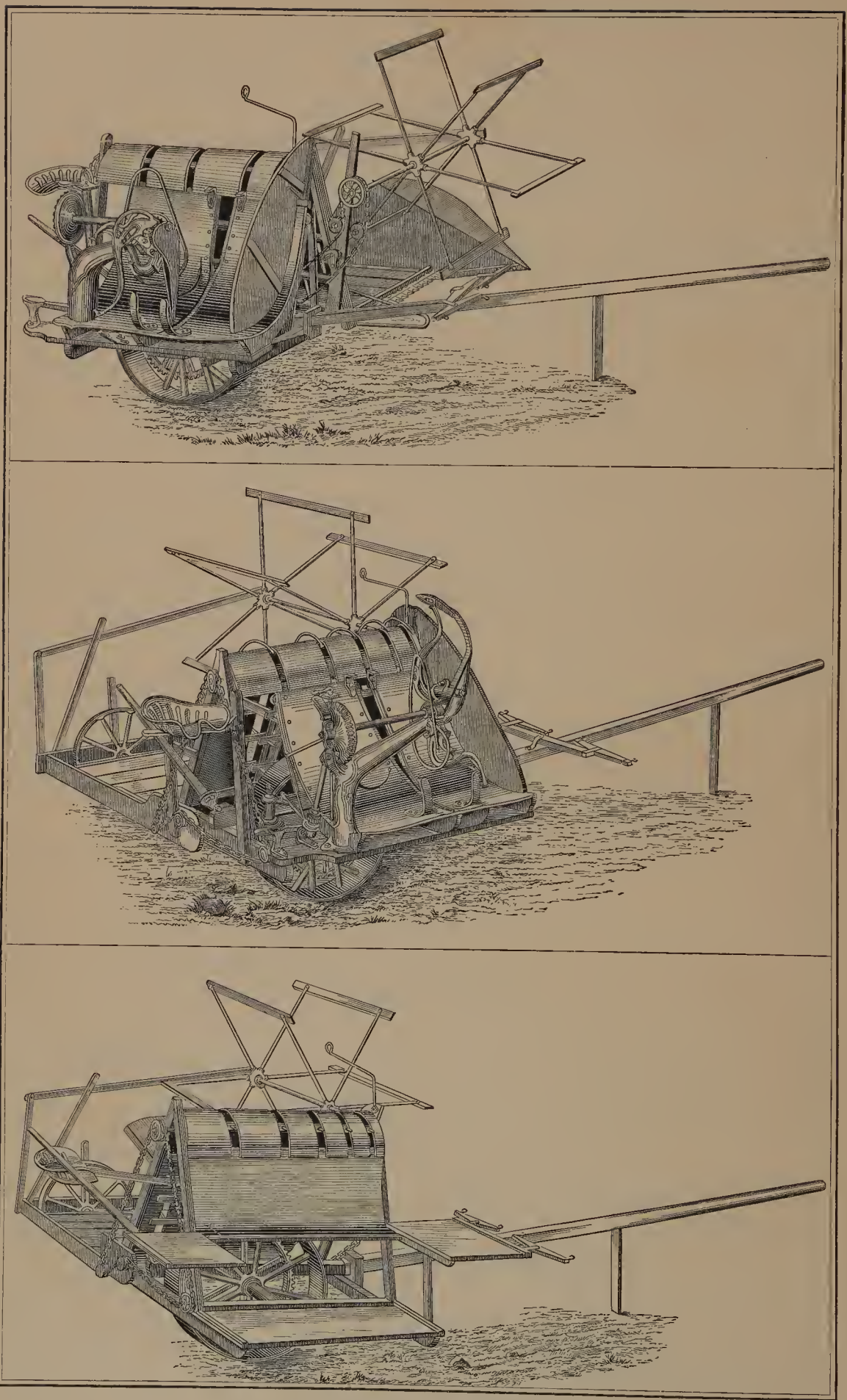


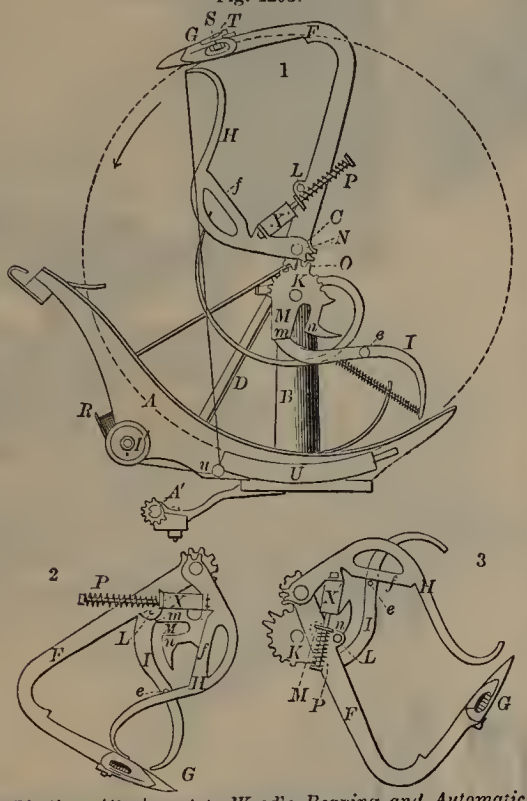
PLATE LI.

SYLVANUS D. LOCKE'S HARVESTER AND BINDER.

(*Machine of* 1874. WALTER A. WOOD, *Manufacturer.*)

See page 1893.

Fig. 4203.



Binding Attachment to Wood's Reaping and Automatic Binding-Machine.

binding problem, after persistent attempts for twelve years past. Some of the machines were sent into the harvest-fields the past summer (1874), and a thousand will probably go out next season.

The grain, as it is cut, falls upon a continuously moving, side-delivery, elevating carrier, and is delivered into the cradle or receptacle *A* of the binder, the operative mechanism of which comprises a right arm *F*, which carries the head *G* with the end of the binding wire and the twisting device, and a compressing arm *H*, both rotating upon a common axis above the cradle, and a vibrating left arm *I*, moving upon an axis parallel with the axis of the arm *F*

The arm *I* is vibrated by the rotation of the arm *F*; in one direction by segment-gear teeth, and in the other direction by a cam and pin.

The motive power is derived from the driving-wheel of the reaper, and is transmitted to the binding arms through a series of shafts with connecting gear-wheels, supported by a crane-post *B*; a treadle-clutch serves to gear or ungear the binding mechanism at will. The binding-wire is supplied from a reel *R* mounted beneath the cradle *A*, and its feed is controlled by a spring take-up and tension *T*.

The end of the binding-wire is held by a nipper at *T*, and from thence passes down through a slit in head *G*, between the leaves of a pinion *S* contained in said head, and thence over the extremity of arm *H* down to the guide-pulley *u* and to the reel.

The rotation of arm *F*, from the position shown in Fig. 1, is accompanied by a movement of the arm *I* in an opposite direction, to bundle, compress, and hold the straw between the arms *H* and *I* (as shown at 2), while the head *G* is conveying the binding-wire completely around it and fastening the ends. The arm *I* then relaxes its pressure, and the bound sheaf is discharged (3). The running and standing parts of the wire are brought together beneath the sheaf by the passage of the head G close to the guide-pulley *u*, whereby the standing part is led into the mouth of the head *G* and between the leaves of the pulley *S* on the side opposite to the end of the wire; at the next moment the head *G* strikes into the rack-box *U*, and the gripper at *T* is caused to open and release the end of the wire, and immediately close again, severing the standing wire outside of the pinion *S* and gripping the new end. The pinion *S* is immediately thereafter caused to revolve by engaging with the rack *U*, to twist together the ends of the wire and complete the band.

In addition to the above general movements may be mentioned the following: When the arm *F* has nearly reached the position shown in Fig. 1, the long teeth *O* engage with the corresponding teeth *N* and advance the arm *H* more rapidly than the arm *F*. This pushes the wire forward, and ensures its engagement with the pinion *S*. When the arm *H* recovers its position by the action of the spring *P*, the wire is retained in engagement with the pinion *S* by a ledge or stop on the under side of the head *G*. The spring *X'* permits the arm *H* to compress the sheaf with an elastic pressure The arms *H* and *I* continue to approach each other until their segment-gears disengage, when the movement of the arm *I* becomes coincident with the movement of arm *F* (2). This is ensured by the engagement of the pin *L* with the shoulder *m* and slot *M*. When the pin *L* reaches the bottom of the slot and impinges against its front side *n*, the arm *I* is advanced faster than the arm *F*, and the sheaf is thereby released (3). The final discharge is facilitated by the engagement of the pin *e* with the cam-surface *f*, whereby the compressor *H* is caused to advance faster than the arm *F* and discharge the sheaf from the machine.

This apparatus is constructed so as to be easily removed from the reaper, either to facilitate transportation, or to permit its place to be occupied by a platform and stand for hand-binders. It is also constructed so that the removal of the arm *I* and some slight changes in other parts of the apparatus enable it to discharge the grain in unbound gavels as a dropper.

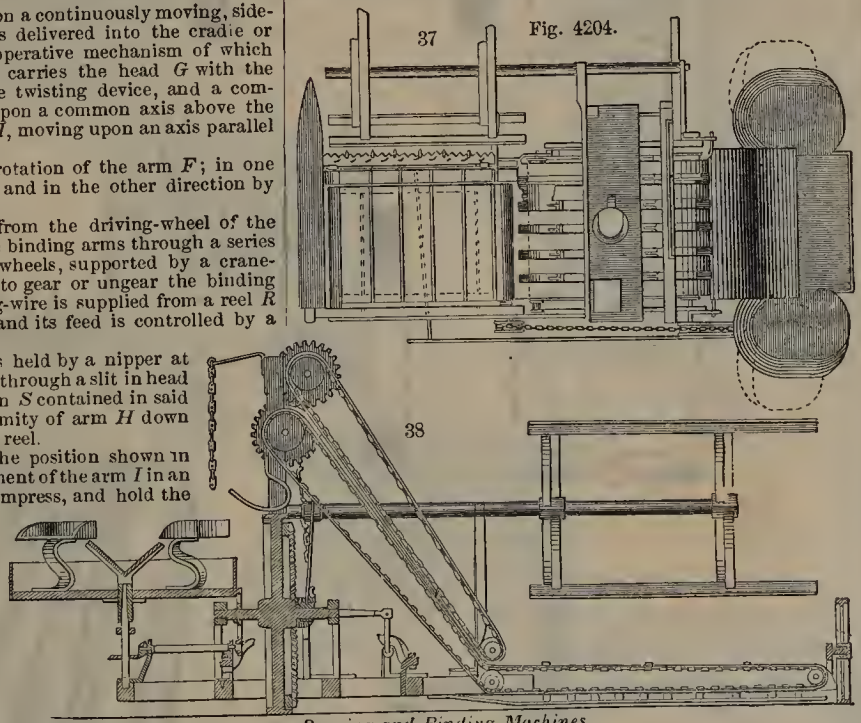
Plate LI shows the machine as a binder in two positions, and also as a hand-binder. In the latter case the two men stand upon the platform and alternately take the gavels from the cradle in which the grain accumulates as it falls down the incline. Each turns to his own binding-table, fastens his band, tips the sheaf off into the stubble, and then turns to gather another gavel.

Among the successful binders must also be noticed that of James F. Gordon, of Rochester, New York. See his patents of August 27, 1872; June 16, 1874; June 30, 1874. Speaking in general terms, his machine has an elevated side delivery, by means of a traveling apron, the grain slides down an incline till arrested by a revolving gaveler, and lies in the bight of the binding-wire. The end of the binding-arm is thrown forward into the twister, carrying the wire around the gavel; the binder-frame then reciprocates, the band is twisted, followed by the cutting of the wire, unclosing of the binder-arm, and dropping of the sheaf.

Barta's self-binder (1871) has also worked successfully in the field. It uses cord, makes a square knot, and binds a gavel of any size, even no larger than the arm.

The following automatic binders may also be consulted: —

Fig. 4204.



Reaping and Binding Machines.

Bowron, January 16, 1872. cord band, secured by wire.
Carpenter, December 22, 1868, wire.
Clinton, July 13, 1869, cord.
Chapman, May 7, 1872, wire.
Fowler, June 7, 1870, stitches woven from gavel.
Withington, February 20, 1872, two wires.
Whitney, May 26, 1874, wire.

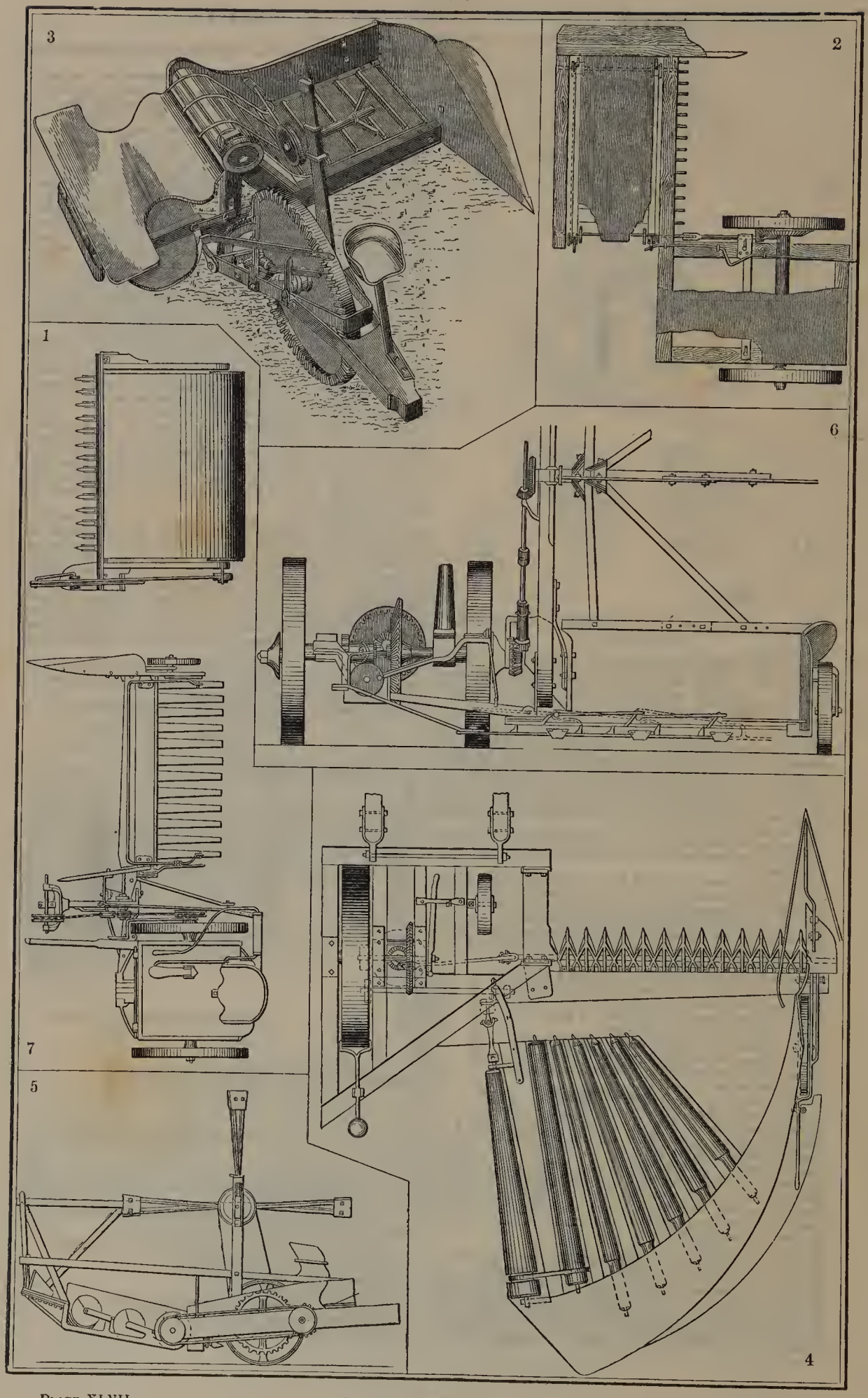


PLATE XLVII.

REAPING MACHINES.

(Principles of Action.)

See page 1893.

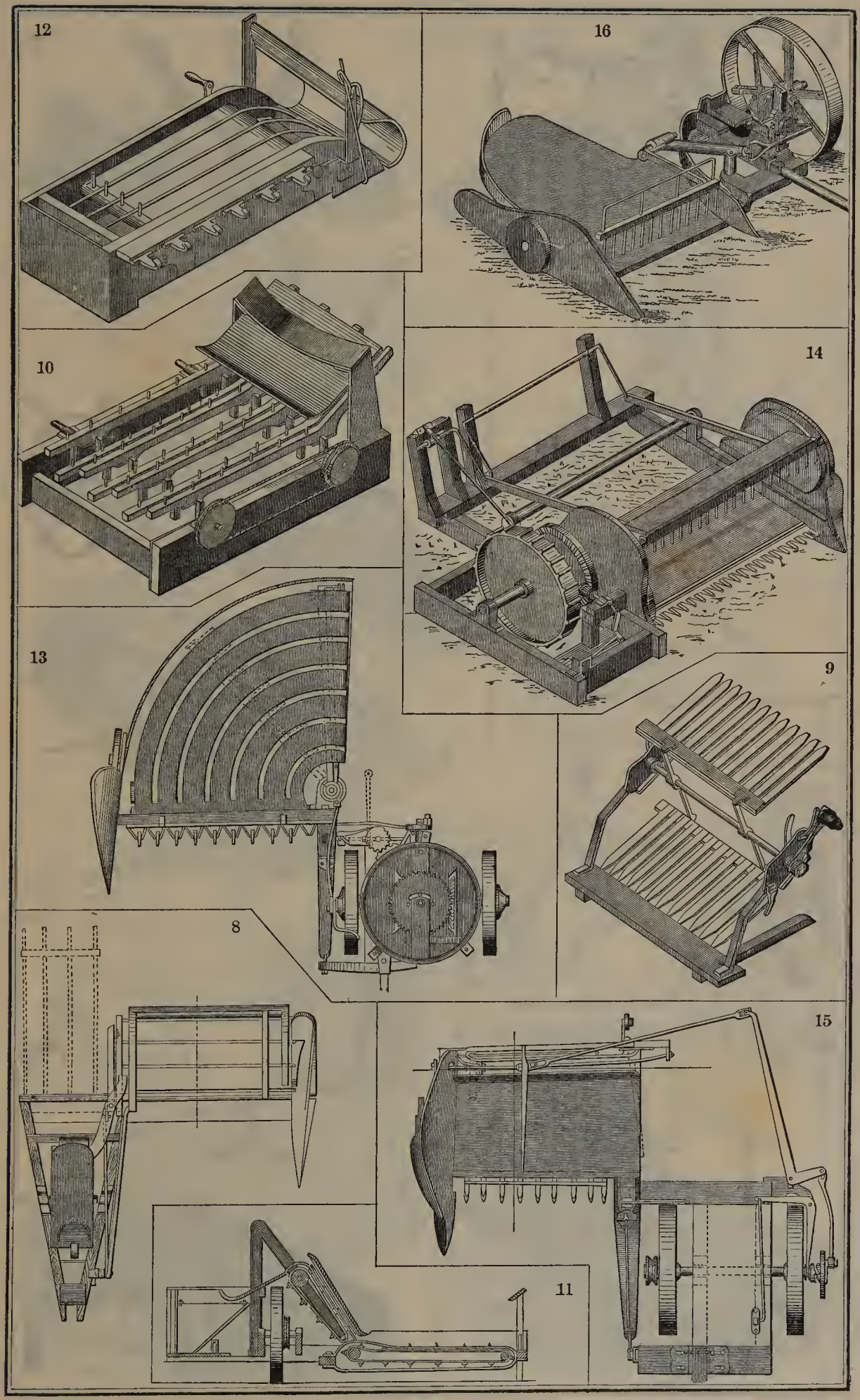


PLATE XLVIII. REAPING MACHINES. *See page* 1893.

(*Principles of Action.*)

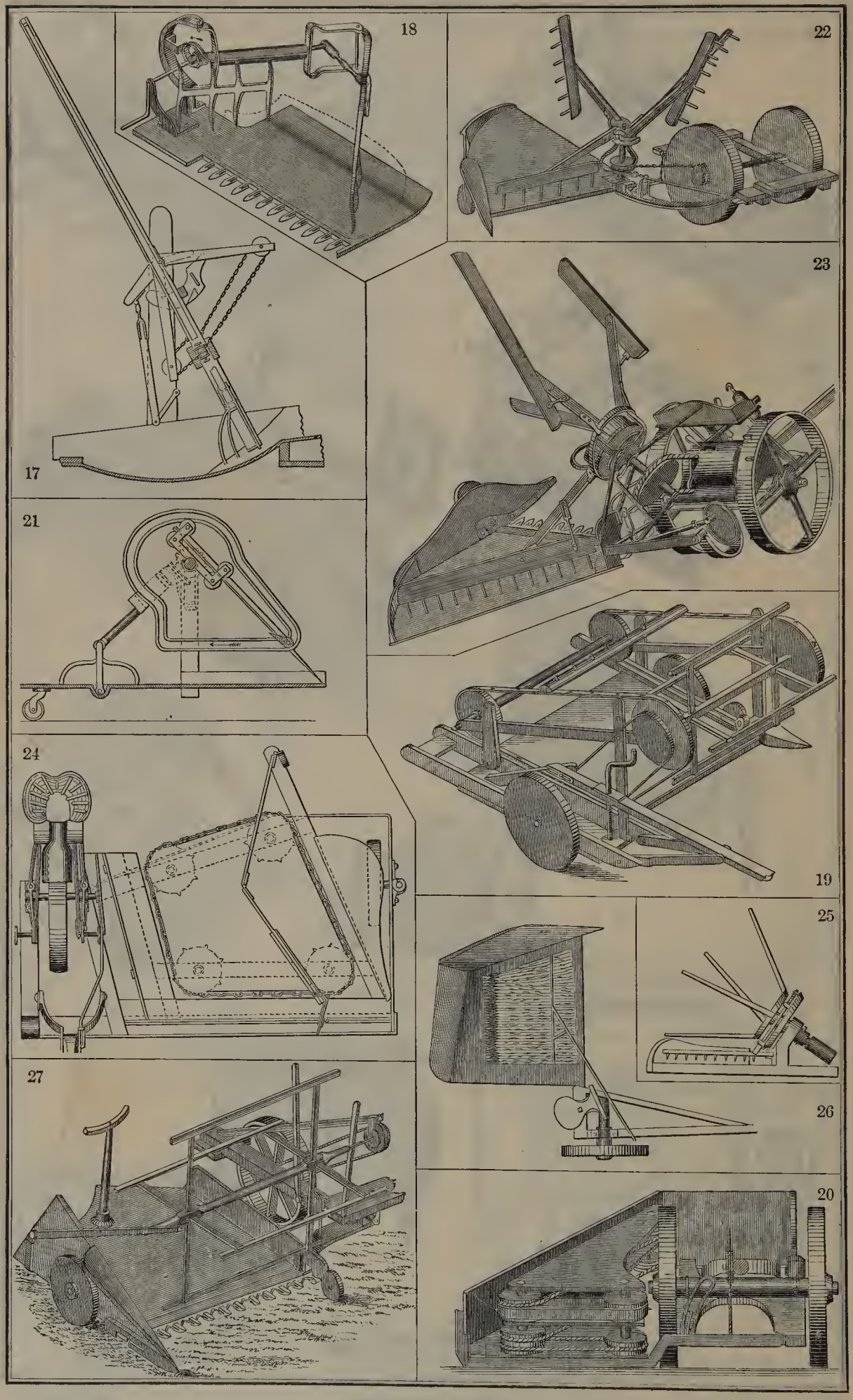


PLATE XLIX. REAPING MACHINES. *See page* 1893.

(*Principles of Action.*)

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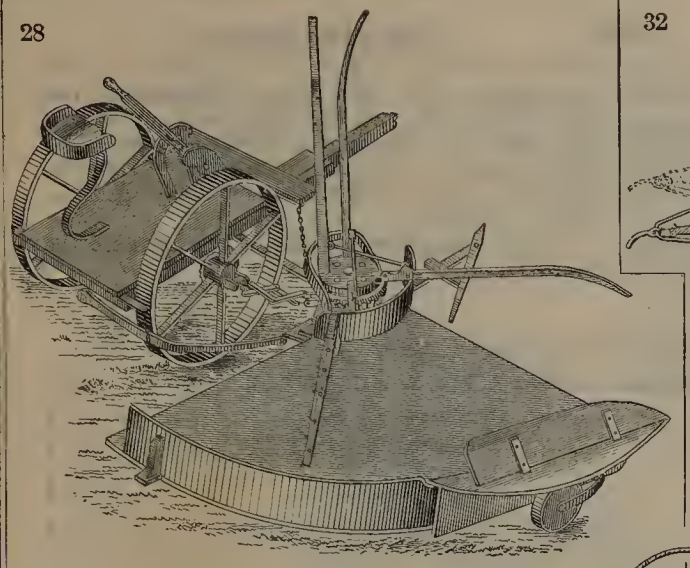

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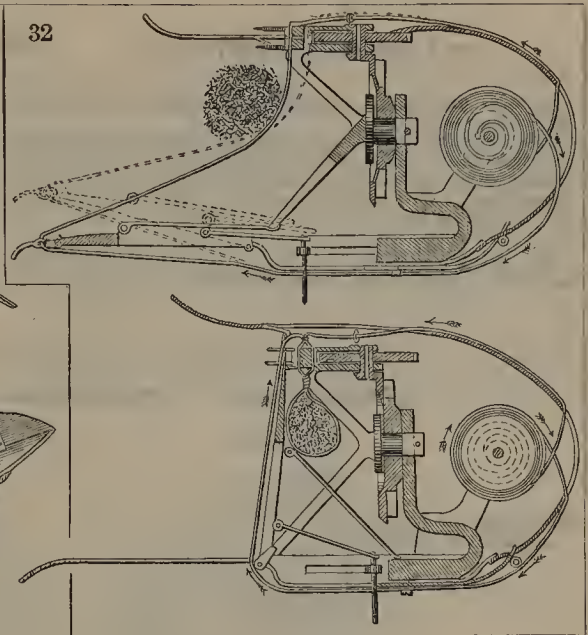

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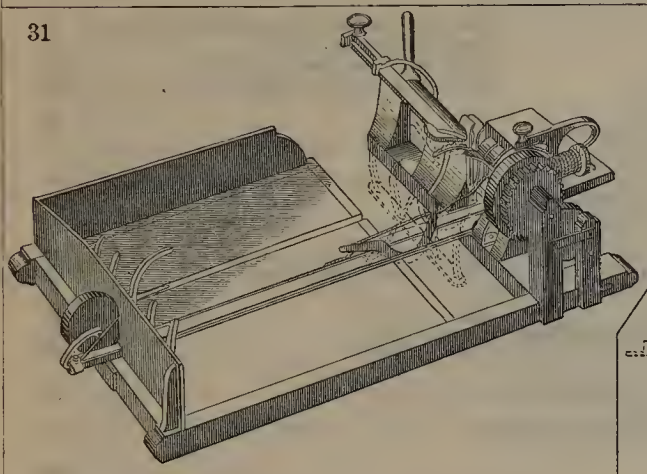

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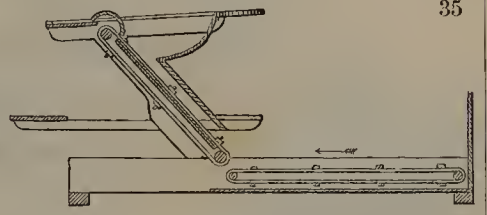

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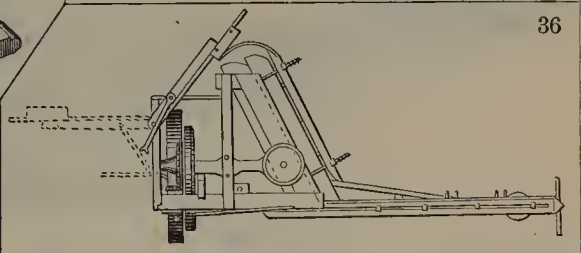

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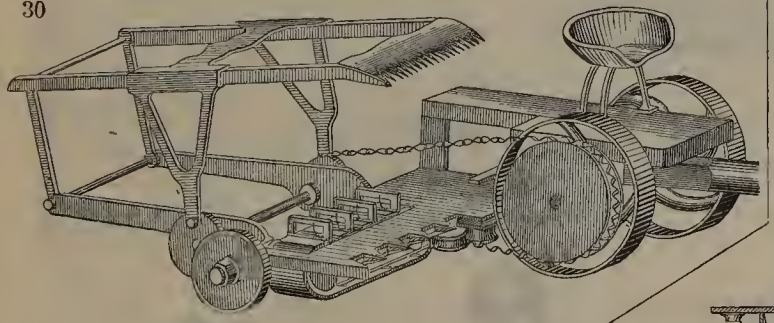

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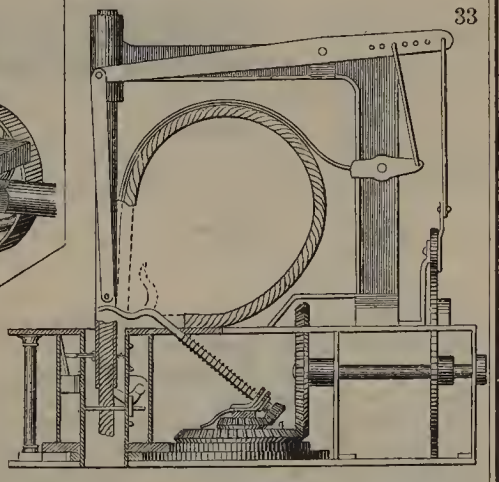

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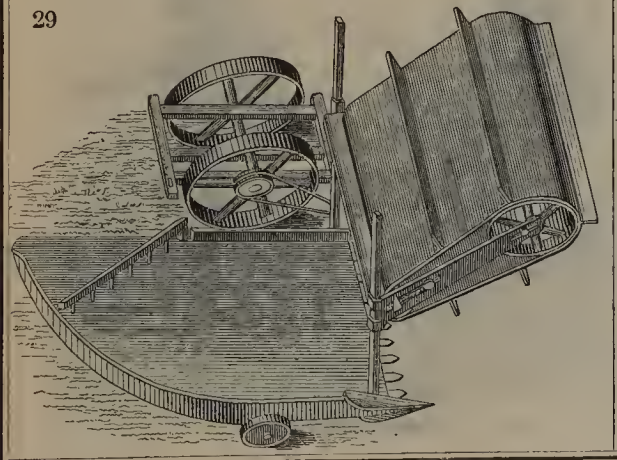

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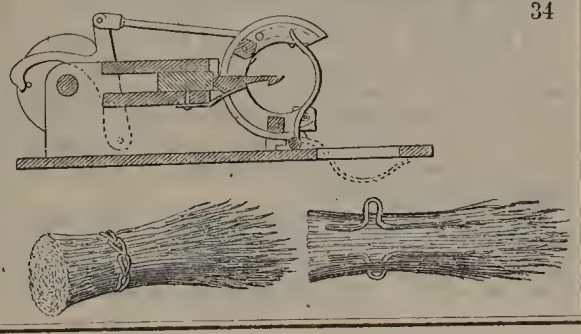


REAPING MACHINES.
(Principles of Action.)

See page 1893.

Fig. 3247, page 1488, is an adaptation of a steam-engine to reaping and mowing.

The implement consists of a boiler and steam-engine, erected on a light wrought-iron girder-frame, the whole being carried on four wheels, of which the two hind wheels are utilized for propulsion and the two fore wheels for steerage and for carrying the cutting apparatus free of the ground.

So far as the *mowing-machines* and *reapers* are identical, they have been referred to under the former head. See chart of mowing-machine motions, Plate XXX., and the classification of *mowers*, page 1488. The drawing and cutting portions of the apparatus are described in the classification referred to, and are illustrated on Plates XXXI., XXXII., XXXIII.

For the distinctive features of a reaper, see the following: —

Classification of Reapers by Structural Features.

The numbers refer to corresponding numbers on Plates XLVII., XLVIII., XLIX., L.

Discharging the gavel by movement of platform	*Endless apron*	Rear delivery			1
		Side delivery	On a level		2
			Elevated		3
	Rollers				4
	Screw-conveyors				5
	Tilting	To one side			6
		To the rear			7
	Swinging				8
	Revolving				9
Gavel discharged from stationary platform	Automatic rake operating above platform	*Teeth operating below platform*	Teeth upon heads hung upon double cranks		10
			Teeth upon endless belts		11
			Teeth upon heads hung on belts		12
			Teeth upon reciprocating heads		13
		Reciprocating	*Rectilinear*	Front to rear	14
				Side to side	15
			Curvilinear	Horizontal path	16
				Vertical	17
				Irregular	18
		Rotary	*Endless belt*	Upon horizontal shaft pulleys	19
				Upon vertical shaft pulleys	20
			About an axis	Horizontal axis	21
				Vertical axis	22
				Inclined axis	23
			Heads connected to an endless belt		24
		Reciprocating and rotary combined			25
	Hand-rakers				26
Reels	Revolving beaters on horizontal axis				27
	Revolving beaters on vertical or inclined axis				28
	Revolving beaters carried on endless belts				29
	Reciprocating rising and falling beaters				30
Binders	*Automatic*	Cord			31
		Wire			32
		Straw rope			33
		Stitches woven from gavel			34
	Hand	Tables rigid			35
		Tables hinged			36
		Tables swinging			37
		Tables revolving			38

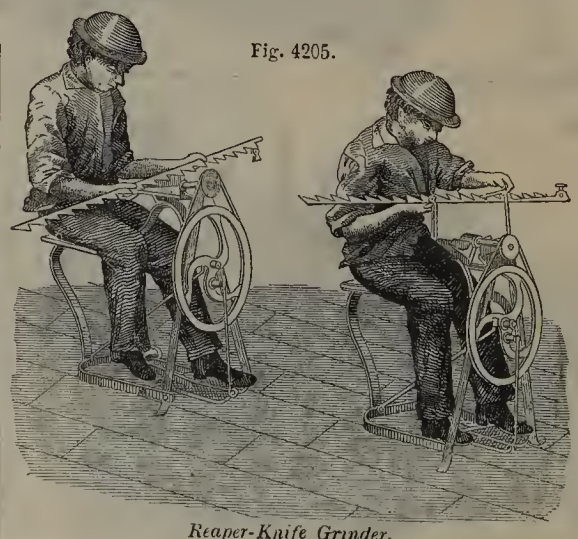
Fig. 4204 shows 37 and 38, the last two forms of binders cited in the classification.

Reap'er-knife Grind'er. A form of grindstone or emery-wheel for sharpening the knives or sickle sections of reaping and mowing machines. In the figure, one shows the machine as adapted for grinding, and the other as having two knife-rests for holding the knife-bar when filing. The emery-wheel is driven by treadle.

In Fig. 4206, the saw is clamped to the adjustable bar at the top of the side frame. The stone has its periphery and a portion of its side faced for grinding. The grindstone standards are upon a horizontal disk which is adjustable upon the carriage. The latter has longitudinal adjustment on the slide bars of the main frame.

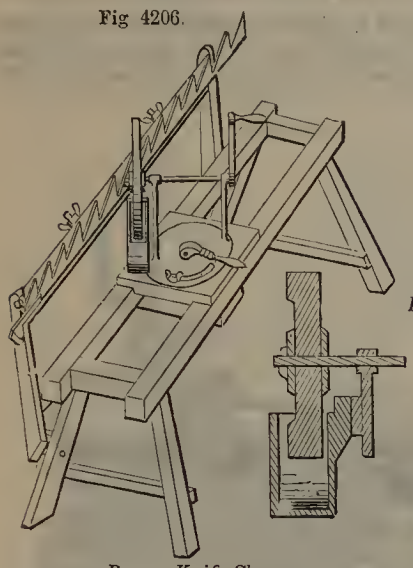
Reap'ing-hook. (*Husbandry.*) The reaping-hook is a curved blade of steel set in a short handle. It has no teeth, and this distinguishes it from the sickle. It superseded the sickle in the

Fig. 4205.



Reaper-Knife Grinder.

Fig 4206.



Reaper-Knife Sharpener.

Fig. 4207.

Reaping-Hooks.

best agricultural counties of England before the reaping-machine appeared.

The Hainault scythe is a reaping-hook. See SCYTHE.

It is called the *scythe-hook* in Scotland, and is there credited to the Irish. The Dutch hook is broad, thin, more nearly circular, but does not *reach* into the grain so far. Ichabod!

Hutton's reaping-hook (English) is serrated from the point through half its length only.

Reap'ing-ma-chine'. (*Husbandry.*) A machine for cutting grain in the field. See REAPER.

Rear'ing-bit. (*Menage.*) A bit having a curved mouth-piece, which forms the flattened side of a ring, to each side of which are attached driving-rein rings, while on the lower side is another ring of the same size, into which the martingale-strap is buckled, to prevent the horse lifting his head when rearing.

Rea'son-piece. (*Building.*) A timber which lies under the beams on the brick or timber in the side of a house. A *wall-plate*. *Raising-piece.*

Reau'mur Ther-mom'e-ter. One in which the space between the freezing and boiling points is divided into 80°, the former being 0°. See THERMOMETER.

Re'bec. (*Music.*) A Moorish violin with three strings tuned in fifths, and played with a bow.

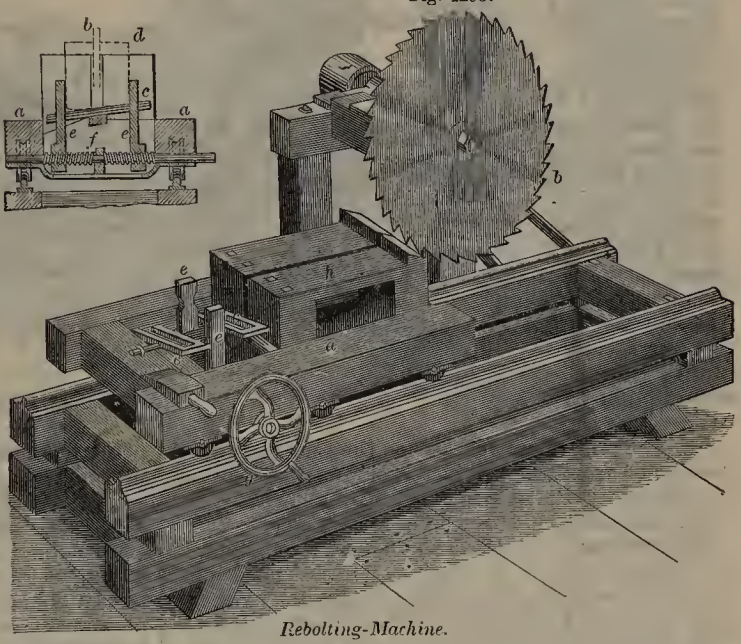
Re-bit'ing. (*Engraving.*) A process for deepening the lines on engraved plates.

The plate is cleaned perfectly and the surface polished. A *ground* is then carefully made by a *dabber*, covering the face only of the plate and not clogging the lines. The parts which do not require *rebiting* are *stopped out*. A wall of wax is then laid around the engraving, the acid solution is poured on, and is allowed to remain till the required depth of lines is attained. As each portion acquires the required depth it is *stopped out*, and the *biting-in* resumed on the remaining exposed parts. See GROUND; ETCHING; BITING-IN; LINE-ENGRAVING, etc.

Re-bolt'ing-ma-chine'. A species of sawing-machine for rebolting large blocks of timber without quite separating the smaller bolts from each other, so that they will hold together, admitting of handling or dogging in the shingling or other machine in which they are to be finally cut up. By this means the machine may be supplied with timber to its full working capacity, while, at the same time, cutting the shingles or other pieces as narrow as desired.

In the perspective view (Fig. 4208) *a* is the carriage which moves under the saw *b*. The depth of the carriage under the blade is such that the latter does not reach the bottom, so that the bolt, secured in the saw-carriage and shown by dotted lines, will not be cut entirely through at *d* in the section. *c* is a tilting rest for the bolt, upon which the sap side of the latter, generally bevel to the other sides, is placed, and held so that the saw kerf will pass down to such a depth as to leave sufficient wood to hold the portions together *e*, core-clamps which work upon right and left hand screws *f*, and are operated by the crank *g*. These serve to hold the bolts securely while being cut. A portion of the carriage *h* is elevated, in order to accommodate pieces which are to be divided entirely, as in ordinary sawing-machines.

Fig. 4208.

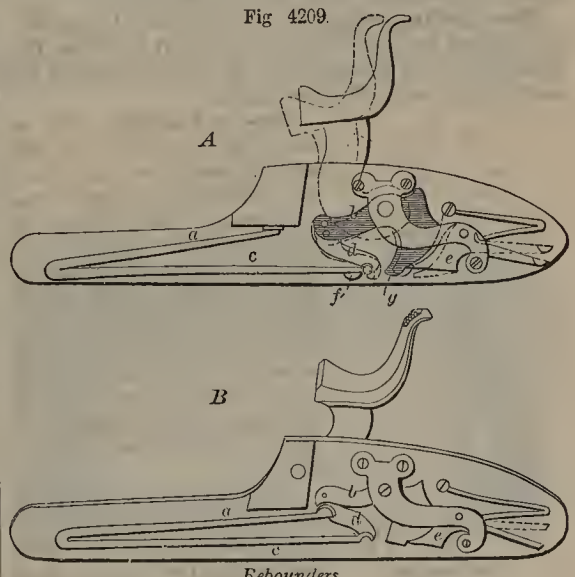


Rebolting-Machine.

The track of the carriage is made in two portions, one above the other, so that the upper part can be vertically adjusted as may be required, for saws of different sizes, or as the blade wears away.

Re-bound'er. (*Fire-arms.*) A device in a gun-lock for throwing the hammer back from the nipple after striking and exploding the cap.

Fig 4209.



Rebounders.

This is usually effected, as at *B*, Fig. 4209, by lengthening the shorter branch *a* of the main-spring so that the arm *b* of the tumbler shall strike it just previous to the impact of the hammer on the cap, caused by the action of the long branch *c* of the main-spring transmitted through the swivel *d*; the effort made by the branch *c* in restoring itself, after the momentary compression, throws back the tumbler sufficiently far to permit the scar *e* to enter the half-cock notch.

In Dane's patent (*A*), used in the Parker gun (see SHOT-GUN), the long branch of the main-spring is arrested by a stop *f* at about the position of half-cock, the tumbler being carried forward by its momentum until it strikes the cap, when the pressure of the sear on the cam-shaped extension *g* throws the tumbler back until the nose of the scar enters the half-cock notch, or sufficiently far to lift the hammer clear of the nipple.

Re-ceiv'er. 1. (*Chemistry.*) A vessel connected with the neck of a retort for receiving the products evolved therefrom during distillation or chemical reaction. See ALEMBIC; CONDENSER; STILL.

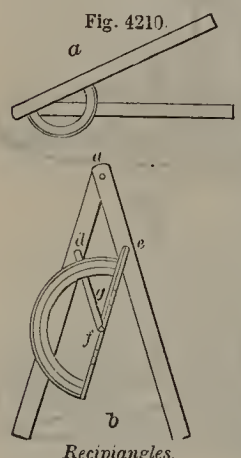
In the laboratory it is frequently made of glass, and is of globular form, but may be of any convenient shape; the material must, however, be such as will not be acted on by the substances to be decomposed or produced during the operation.

2. (*Pneumatics.*) *a.* The bell-glass on the table of an air-pump.

b. The vessel which is adapted to collect the gas from the PNEUMATIC TROUGH (which see); or to contain gas for blow-pipes, exhibitions of stereopticons, oxyhydrogen light, or microscopes.

Re-ceiv'ing-mag'net. (*Telegraphy.*) An electro-magnet through which the current from the line wire passes and is intensified, in order to actuate the sounding or recording mechanism.

Fig. 4210.

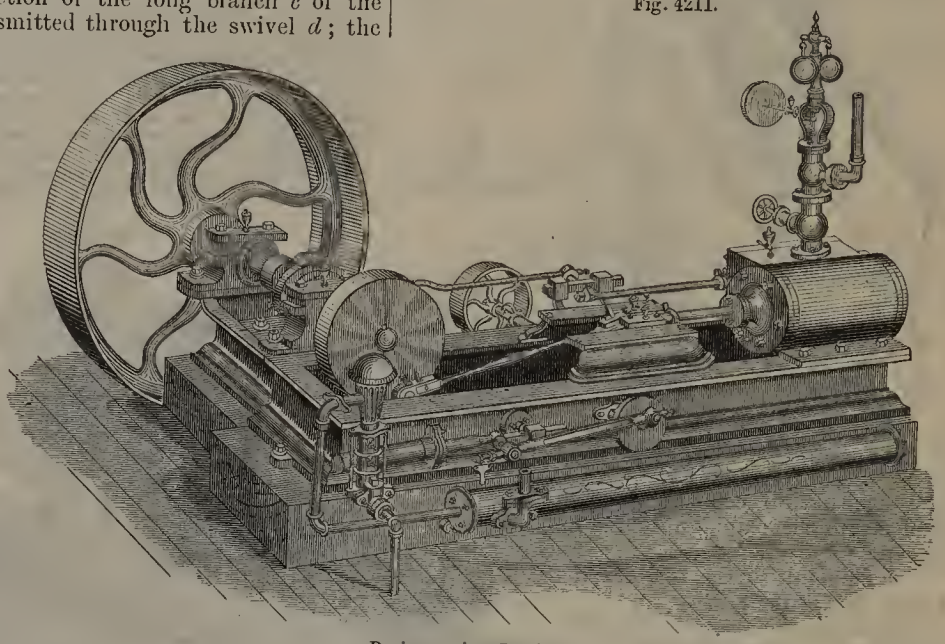


Recipiangles.

Re-cip'i-an'gle. An instrument (*a*) with two legs and a graduated arc, used by military engineers for measuring and laying off angles of fortifications. The legs are attached at one end by a double-headed screw, which forms the axis. The center of the protractor is applied at the reëntering angle of the instrument, and its graduated margin shows the angle of divergence of the legs.

Another form (*b*) of the *recipiangle*, called the *parallelogrammatic*, has two links connecting the legs and meeting at the center *f*. The length between the points *a d* and *a e* is exactly equal to the distances *d f* and *c f*, so that when the legs are brought into line, the point *f* coincides with the point *a*. The center of the protractor is exactly over the point *f*, which also bisects the angle of the instrument at all adjustments. The marginal graduation of the protractor permits the angle subtended thereby to be read. The protractor is hinged at *g*, so that it may be lifted and stand perpendicular to the plane of the instrument. The instrument is adapted for taking salient or reëntering angles.

Fig. 4211.



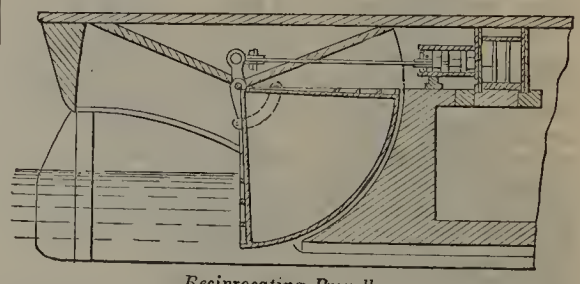
Reciprocating-Engine.

Re-cip'ro-cat'ing-en'gine. (*Steam-engine.*) The common form of engine, in which the piston and piston-rod move back and forth in a straight line, absolutely as in the cut, or relatively to the cylinder, as in oscillating-cylinder engines.

The term is used in contradistinction to ROTARY-PISTON ENGINE (which see), and is a very general one, including as it does by far the greater number of steam-engines, either devised or in use.

Re-cip'ro-cat'ing-pro-pel'ler. One having a paddle which has a limited stroke and returns in the same path. The propeller is reciprocated by a horizontal engine. It is enveloped at the sides and before, so that the water does not impinge against its forward side. The propeller is made sufficiently buoyant to raise it to position for making the effective stroke.

Fig. 4212.

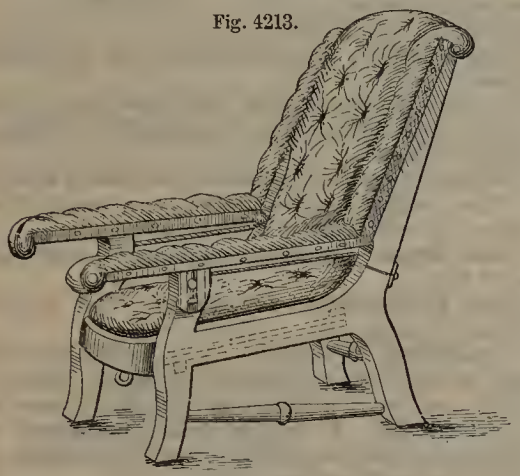


Reciprocating-Propeller.

Re-clin'ing-chair. One whose back admits of

being tilted, allowing the occupant to assume an inclined or recumbent posture. In the figure, the back is hinged near the seat, and a given inclination is maintained by the engagement of notches beneath

Fig. 4213.



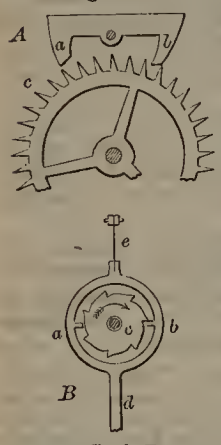
Reclining-Chair.

the arms, with spring teeth on the front posts. A slide in front forms a foot-rest. Spring cords erect the back. See FOLDING-CHAIR; INVALID-CHAIR; CAR-SEAT.

Re-coil'-es-cape'ment. A recoil-escapement is one in which, after the pallets leave the teeth at each oscillation of the pendulum, the extremities of the teeth slide along the surfaces of the pallets, and thereby give an impulse to the pendulum or balance.

The *vertical* escapement of a watch is a *recoil*, and the word is used as distinguished from a *dead-beat*. In the former there is a recoil of the train, and in the latter the impinging surfaces of the pallets are cut to a curve concentric with the axis of vibration, and during the time one of the teeth is against the pallet the scape-wheel remains perfectly at rest. See ESCAPEMENT; DEAD-BEAT.

Fig. 4214.



Recoil Clock-Escapements.

The anchor-escapement *A* was invented by Clement, of London, about 1680. The anchor is caused to vibrate on its axis by the oscillations of the pendulum. The teeth of the scape-wheel *c* impinge alternately against the outer surface of pallet *b* and the inner surface of pallet *a*. As these surfaces are not concentric with the axis of oscillation, a *recoil* of the train ensues, for the reason just stated, that as the pallets leave the teeth, the extremities of the latter slide along the acting surfaces of the pallets, and through them transmit a sufficient impulse to the pendulum to overcome the loss by friction and the resistance of the atmosphere. See also Fig. 193, page 97.

Another clock-escapement *B* has a pallet-ring surrounding the scape-wheel *c*, the pallets *a b* projecting from its internal periphery and catching alternately, as the pendulum rod *d* oscillates, upon teeth on opposite sides of the scape-wheel.

The pallet-ring is suspended by a piece of watch-spring *e* from a stud.

Re-cord'er. 1. (*Music.*) A musical instrument like a flageolet.

"Flutes and soft recorders."

MILTON.

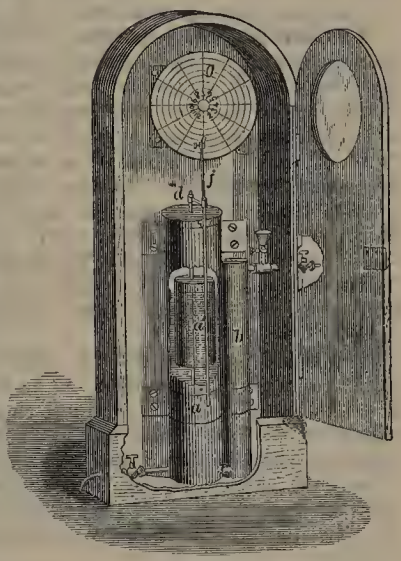
"To Drumbleby's, and there did talk a great deal about pipes; and did buy a recorder."—PEPYS'S *Diary*, 1668.

It was used in teaching birds to pipe.

2. A registering apparatus. See REGISTER.

Re-cord'ing-gage. Generally speaking, any gage provided with means for leaving a visible record of its indications.

Fig 4215.

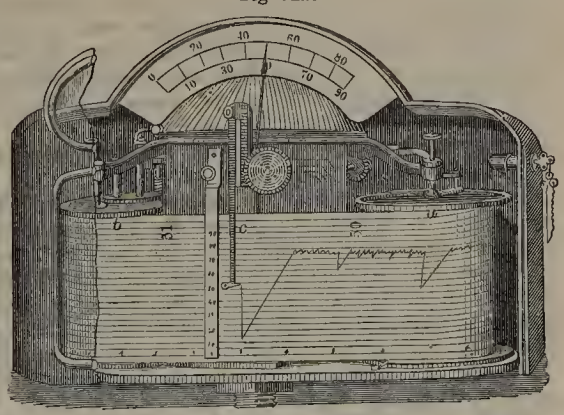


Recording-Gage for Gas.

That shown (Fig. 4215) is particularly designed for measuring gas pressures. The two cylinders *a b* connected by a short pipe *c* are partially filled with water. *a* contains a float *a'* having an upwardly projecting rod *d* passing through a hole in its cover and connected with a guide-rod which carries a pencil-holder at the end of a flexible spring *f*, by which the pencil is caused to press against a disk of cardboard *g*, ruled with radial divisions for the hours and circular divisions for inches of pressure, and rotated by clock-work. Gas being admitted to the upper part of the cylinder *b* depresses the water therein, and causes a difference of level in the two cylinders which varies as the gaseous pressure fluctuates, its amount being registered by the line traced by the pencil on the cardboard, which is renewed at intervals of twelve hours. See also SPEED-RECORDER.

Edson's recording-gage (Fig. 4216) has several air and steam tight connected drums made of thin elastic metal; these, on being expanded by the influx of steam, raise a rod attached to the upper drum, which operates a segment-rack connected by gearing with a horizontal rack and a pawl, causing a partial slight rotation of the drum *a*, which consequently draws forward the paper previously wound upon the roll *b*, on to itself. The expansion or contraction of the connected drums also raises or depresses the arm

Fig. 4216.



Edson's Recording Steam-Gage.

c, carrying a pencil or tracer at its lower extremity, making vertical or diagonal lines on the paper, which is ruled with horizontal lines indicating pounds, as the steam-pressure varies. The rolls may also be rotated by connection with the engine, affording a more continuous record. A graduated arc and pointer are attached, to more conveniently show the pressure at the moment; and a hammer and bell or other device may also be connected to sound an alarm when the pressure exceeds a given amount. See STEAM-GAGE.

Re-cord'ing-tel'e-graph. A telegraph provided with an apparatus which makes a record of the message transmitted, as the symbol telegraphs of Morse and Bain, and the type-printing telegraphs of House and Hughes, in contradistinction to the indicator-telegraph of Cooke and Wheatstone, which has a pointing needle or needles, and the audible one of Sir Charles Bright, which sounds upon bells, and the Morse as at present generally used, which is read by the sounds. See List under TELEGRAPH.

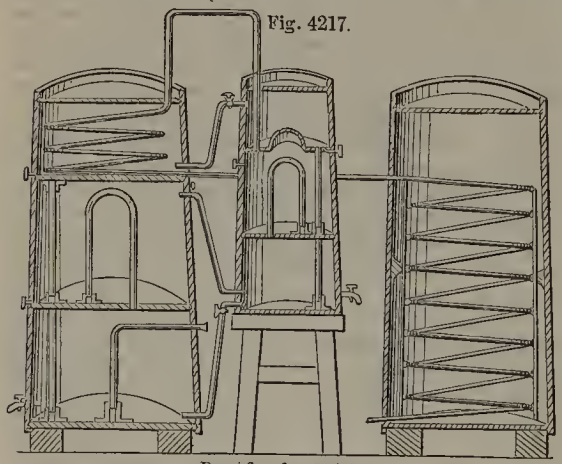
Rec'ti-fi-ca'tion. Redistillation or resublimation to free a substance from impurities or from water.

Rec'ti-fi'er. 1. A second still for redistilling spirits, or a second chamber connected to the main or primary still. In the rectifier, the *low wines* are redistilled to concentrate them; or *high wines* are farther concentrated and purified to form alcohol.

In some cases, flavoring matters, such as oil of juniper, to form gin, are placed with the *low wines* for redistillation; or the flavor is added in the form of vapor.

In Fig. 4217, the tub has three chambers and means for heating the *singlings* before charging the lower chambers, so as not to check the continuous

Fig. 4217.



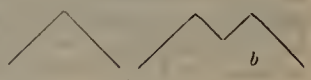
Rectifier for Spirits.

process of evaporation incident to the use of a single-chambered vessel. The upper chamber receives the low wines, and they are heated by the steam in the middle chamber. The chambers are charged successively from the upper one, and provision is made for avoiding collapse and for carrying off vapor.

2. (*Nautical.*) An instrument for determining the variation of the compass on board ship. It consists of two circles, either laid upon or let into each other, and so fastened together in their centers that they represent two compasses, the one fixed, the other movable; each is divided into 32 points of the compass and 360°, and, numbered both ways from the north and the south, end at the east and west in 90°. The fixed compass represents the horizon, in which the north and all the other points are liable to variation. — ADMIRAL SMYTH.

Re-dan'. (*Fortification.*) A work having two faces forming a salient angle in the direction from which an attack may be expected; it is open at the gorge.

Fig. 4218.



Redans.

A *double redan* (*b*), or *bonnet deprêtre*, has a reëntering angle for mutual defense.

The *redan* is the simplest field-work, and is used for defending the avenues of approach to a village, bridge, or defile.

In front of another field-work, it is called a *flèche*.

When *flanks* are added to the *faces*, the work becomes a *detached bastion* or *lunette*.

Red Brass. An alloy containing 8 parts copper and 3 zinc.

Red Brick-dust. (*Foundry.*) Used as *parting-sand* (which see).

Re-doubt'. (*Fortification.*) *a.* A detached field-work inclosed by a parapet, the salient points of which are but imperfectly or not at all protected by a flank fire. It may be square, star-shaped, or irregular in plan, according to the requirements of its site and surroundings.

b. An interior work within the main line of ramparts, as the *redoubt* of the *ravelin*, *redoubt* in the *places-of-arms*. See RAVELIN.

These are designed as places of assemblage in offensive exterior operations, or for retreat in case of a repulse.

Red-short Iron. Iron which is difficult to weld and is brittle when heated is said to be *red-short* or *hot-short*. This defect is due to the presence of sulphur.

Red-staff. (*Milling.*) A straight-edge employed to detect irregularities in the face of a millstone. The edge is reddened with ocher, and colors prominent irregularities on the face of the stone.

Red-stuff. A trade term for the oxides of iron used in grinding and polishing, such as *crocus* and *rouge*.

Red Tom'bac. An alloy containing 11 parts copper and 1 zinc.

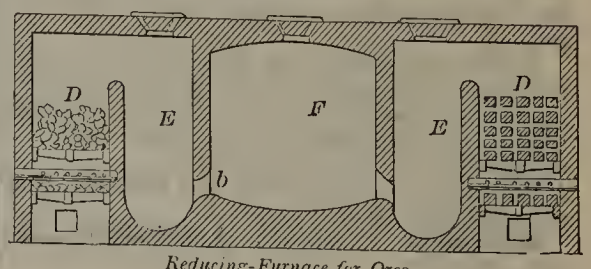
Re-duc'ing-fur'nace. (*Metallurgy.*) A furnace in which ores are deprived of their oxygen and reduced to the metallic state by the action of intensely heated vapors containing carbon, sometimes assisted by other reagents.

It is generally of the reverberatory kind, and is used in the reduction of litharge, the treatment of copper ore in several stages, and for obtaining the precious metals. See BLAST-FURNACE; REVERBERATORY-FURNACE; SMELTING-FURNACE; and others cited in the lists under METALLURGY and FURNACE.

Siemen's furnace has two parallel sides sloping downward, so as to form a kind of trough between them. The ore is charged at both sides on the top of the furnace, and slides down the inclined planes of the two sloping sides. At the bottom of the furnace the gases from the producer and the necessary supply of air are admitted, and produce an intense flame, the products of combustion rising upward through the masses of ore, which are acted upon in a similar manner to that in the blast furnace.

Maunton's furnace (Fig. 4219) has regenerators *D D* and

Fig. 4219.

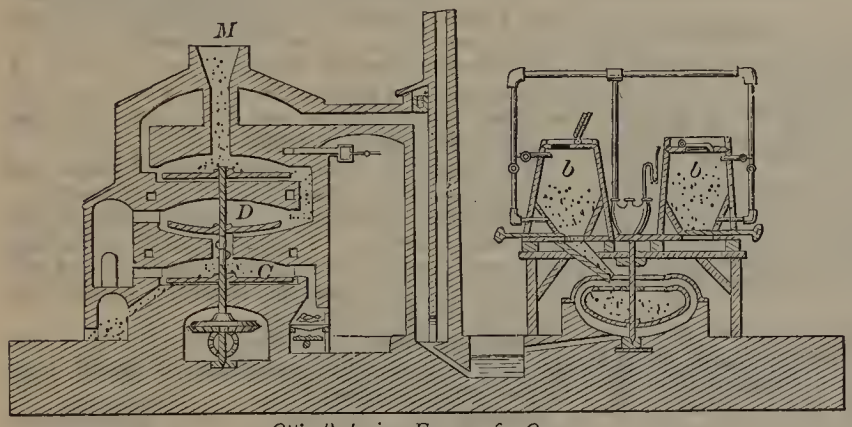


Reducing-Furnace for Ores.

fuel-chambers *E E* on each side of the reducing-chamber *F*, which is charged with finely comminuted ore. The hot-air blast is caused to pass into the reducing-chamber *F* alternately from the regenerators *D D* through openings *b* at its base.

In Ott's furnace for reducing the precious metals (Fig. 4220), the ore, having previously been separated from a portion of its impurities, may be mixed with two to four per cent of sodium, potassium, calcium, magnesium, iron, copper, or with their hypochlorites. The ore, dry or with water, is introduced through the funnel *M*. In the upper oven the ore is heated. In the second oven *D*, where sulphur is eliminated, the steam and hot air are injected, and most of the sulphur is carried off. In the lower oven *C* it is farther heated and treated with hydro-carbonaceous vapors from the furnace to decompose the sulphates. The volatile metals passing off from this chamber are condensed

Fig. 4220.



Ott's Reducing-Furnace for Ores.

in the shower-bath of the diving-flue. Hyponitrous-acid gas or oxygen may be introduced into the furnace. If the ore be auriferous it is placed in the tanks *b b*, dampened with steam, and saturated with chlorine gas, after which it is treated in the centrifugal machine. If the ore be argentiferous it is brought from the furnace immediately to the centrifugal machine and treated with hot water returned several times over and over the same ore, and the liquid resulting from that treatment is pumped up from the lower tank to the upper tank, and from thence falls in a fine shower down the diving-flue, where the sulphureted hydrogen produced in the furnace precipitates the silver in form of sulphite. This is repeated several times. The sulphite is melted with iron, producing sulphuret of iron and silver.

Re-duc'tion-com'pass-es. *Proportional* dividers or *whole-and-half* dividers.

Reed. 1. (*Weaving.*) Called also the *sley* or *slay*. An appurtenance of the loom, consisting of two parallel bars set a few inches apart and furnished with a number of parallel slips of metal or reed, called *dents*, between which the warp-threads are passed. The lengths of reeds are estimated in quarters of a yard, as $\frac{3}{4}$, $\frac{4}{4}$, $\frac{5}{5}$, $\frac{6}{4}$, etc., and, if necessary, by a smaller fractional denominator, as $\frac{7}{8}$, $\frac{9}{8}$, or $\frac{13}{16}$, $\frac{15}{16}$, etc.

In Scotland they are estimated thus: —

20 splits ..... 1 porter.
5 porters ..... 1 hundred.

In other parts of Britain the estimate is by the number of *splits* or *dents* in 24½ inches, or in 1 inch.

The reed is set in a swinging frame, called the *lathe*, *lay*, or *batten*. In the hand-lathe, the bottom of the batten is furnished with a shelf, called the *shuttle-race*, along which the shuttle is driven.

The office of the reed is to beat the *weft* up to the *web*, and the force of the blow determines the compactness of the fabric. Two threads of yarn pass between each of the *reed-splits* or *dents*.

The number of *dents* in a reed of a given length determines the fineness of the cloth.

One form of linen-prover has 4 perforations to adapt it to the varying modes of estimating. The number of threads visible in this perforation ascertains the number of threads in the standard measure of the *reed*.

The first is ¼ of an inch in diameter, and is intended to ascertain the number of threads per inch.

The second is for the Holland reed, being $\frac{1}{200}$ part of 40 inches.

The third is $\frac{1}{700}$ part of 37 inches, and is adapted to the Scotch reed, so called by Ure, as being the regulation reed of that country.

The fourth is $\frac{1}{200}$ of 34 inches, and is adapted for the French cambrics.

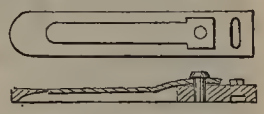
Two warp-threads count for 1 split.

2. (*Music.*) *a.* Formerly, an instrument made from a reed with holes to be stopped by the fingers.

b. A vibrating musical tongue of wood or metal (formerly made from a *reed*).

It is used in wind-instruments of two classes.

Fig. 4221.



Melodeon-Reed.

1. The *oboe*, *clarinet*, *bassoon*.

2. The *accordeon*, *concertina*, *melodeon*, *harmonium*, *parlor-organ*, and that variety of pipe in the large organ known as the *reed-pipe*, in contradistinction to the *flute* or *mouth pipe*. See ORGAN-PIPE.

Some reeds batter against the seat and some are *free*.

3. (*Mining.*) The tube conveying the train to the charge in the blast-hole. Also called the *spire*.

4. (*Ornamentation.*) *a.* Semi-cylindrical ridges, closely arranged in parallel order and designed for ornament.

b. A succession of beads on an object.

Reed'ing. This term is applied (technically) to the *nurling* on the edge of coins. It was originally placed upon coin to prevent it being filed away or clipped. It is done at the same time that the impression is given to the obverse and reverse faces of the coin, the collar which holds the blank being *fluted* or *indented* on its inner periphery for that purpose. The pressure on the dies expands the metal into the indentations of the collar, giving the *reeded* or *crenated* form to the edge.

It is sometimes called *milling*, but that term is also applied to the swaging pressure by which the edge is expanded and a flange raised, which protects the faces of the coin and enables them to be built into a pile.

Reed-or'gan. (*Music.*) A melodeon, or parlor-organ.

An organ whose pipes are provided with *reeds*, in contradistinction to the *flute* or *mouth* organ, whose pipes have a lip to cut the wind escaping through an aperture in a diaphragm. See FLUTE-ORGAN.

The *reed-pipes* consist of a foot to carry the wind to the reed, a thin tongue of hard brass, whose extremity is fitted into a mold by a wooden plug. Its free extremity is vibrated by the force of the wind, and gives a sound of a pitch proportioned to the length, thickness, and elasticity of the tongue.

The wind from the reed traverses a long pipe, which gives character and quality to the sound. Both classes of pipes are employed in large organs.

Reed-pipe. (*Music.*) An organ-pipe in which the musical tone is produced by the vibration of a metallic tongue.

In some reed-pipes the tongue is made to batter against its seat as in the clarinet; in others the tongue plays in the opening of the reed. The *free-reed* has been used in China from time

immemorial, but was introduced into Europe by M. Grenié in 1810.

The reed or tube has a longitudinal, narrow opening in front, covered by the *tongue*, which is firmly fixed to the reed at its upper end, but plays freely at the lower end, where it is somewhat bent away from the *reed*. A *turning wire* presses against the tongue so as to regulate the length of the portion subject to vibration. The reed terminates below in a cone, into which the air is driven. The shape of the tube above the cone is varied so as to obtain the required quality of tone, while the pitch depends upon the length, thickness, and elasticity of the tongue. A given number of vibrations per second are necessary to the production of a certain note; the slower the vibrations, the graver the tone, and conversely. See PIPE.

The free-reed, instead of beating on the edges of the opening, plays back and forth in the slot.

Reed-plane. (*Joinery.*) A concave-soled plane used in making beads.

Reed-stop. (*Music.*) A set of pipes furnished with *reeds*, and associated with the *flute*-stops of an organ, to give a variety to the effects.

Reef. (*Nautical.*) *a.* The portion of a square sail between the head of a sail and any of the *reef-bands*. On the *tablings* of the *leech* of the sail are *earings* and *cringles*, to which the *reef-tackle* is secured. The reef is tied up by *reef-points*, the knot being a *reef-knot*. The *first reef* in a square sail is included between the head and the upper reef-band; the *second reef* between this and the next lower reef-band, and so on.

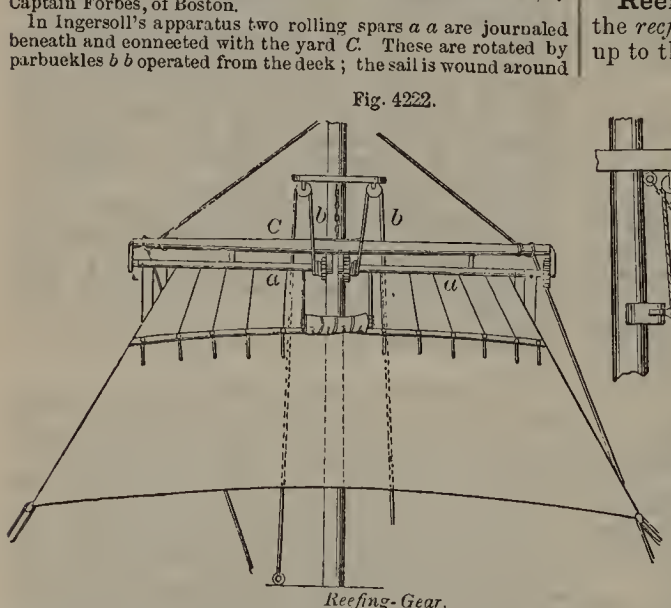
Fore-and-aft sails are reefed from the foot, the first reef being the lowest. The uppermost, called a *balance* reef, extends diagonally upward from the outer leech when *close-reefed;* that is, when all the reefs are taken in, the area of the sail exposed to the wind is reduced about one half.

The object of the reef is to diminish the surface of the sail when the wind is blowing hard.

In the ordinary process of reefing square sails, the seamen ascend the rigging and *lay out* on the yard, standing on the *horses* or foot-ropes while they gather in and secure the hauled-up portion of the sail. Many attempts have been made to avoid the necessity for this difficult and dangerous operation, which is a fruitful source of accident. The first, we believe, was by Captain Forbes, of Boston.

In Ingersoll's apparatus two rolling spars *a a* are journaled beneath and connected with the yard *C*. These are rotated by parbuckles *b b* operated from the deck; the sail is wound around

Fig. 4222.



Reefing-Gear.

them to any desired extent, and prevented from unrolling by ratchets and pawls at their ends.

b. The bowsprit of a cutter or that of a ship-of-war with a ram-bow is said to *reef* when it is run-in or shortened by sliding in-board.

c. Reefing the paddles in steamships is effected by disconnecting the float-boards from the paddle-arms, and bolting them again nearer the center of the wheel, to diminish the dip when the vessel is deep.

Reef-band. (*Nautical.*) A strong horizontal strip of canvas extending across a sail at right angles to the lengths of cloth.

In square-rigged vessels there are four of these bands to the topsails, from three to six feet apart, according to the size of the sail, and two bands to the foresail and mainsail. Fore-and-aft sails have also a band extending diagonally upward from the outer leech, for balance-reefing.

Each band is pierced with holes for the *reef-points*, by which it is tied to the yard in shortening sail.

Reef-knot. (*Nautical.*) A knot formed by passing the ends of the two parts of one rope through the loop formed by another whose two ends are similarly passed through a loop on the first; the two parts of one rope are passed above, and of the other below the loop through which they are inserted. A longitudinal pull tightens the knot, which can only be untied by pushing the loops in opposite directions.

Called also *square-knot*, *flat-hitch*.

When one end of one rope is passed above and the other below the loop it forms a *granny's-knot*.

Reef-line. (*Nautical.*) A line sometimes (seldom) used in reefing. It passes spirally around the yard, and through the eyelets in the reef-band successively, so as to draw the latter up to the yard when the line is hauled upon.

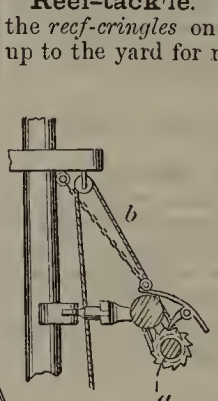
Reef-pen'dant. (*Nautical.*) A tackle by which the after leech of a fore-and-aft sail is drawn down to the boom in reefing.

Reef-point. (*Nautical.*) One of the flat pieces of braided cord attached by eyelets to the *reef-band* of a sail, and serving to diminish its area.

The *reef-band* has usually two holes in each width of cloth, and the *points* taper toward each end. The small end of each is passed through an eye in the large end of the other, and being rove through the eyelets in the *reef-band*, one hangs down before and the other abaft the sail.

Reef-tack'le. (*Nautical.*) A tackle by which the *reef-cringles* on the leeches of a sail are drawn up to the yard for reefing.

Reel. A revolving device on which fiber, thread, cord, rope, fabric, etc., are wound, to form them into hanks or skeins, and for various other purposes.



1. (*Cotton-machinery.*) A machine on which cotton is wound, making hanks each having 840 yards in length of thread.

The circumference of the *reel* is 4½ feet; when it has performed 80 revolutions a *lay* is formed, measuring 120 yards, and 7 of these lays make up a *hank*.

The hank-yarn is specially designed for warps.

2. (*Silk.*) The revolving frame on which silk is wound from the cocoons, or yarn is wound off from the spindle of a hand-spinning machine, and reeled into cuts or hanks.

3. (*Rope-making.*) Spun yarns are wound on a reel preparatory to tarring or laying up into strands as the twisting of each length is completed. See ROPE.

4. (*Nautical.*) A revolving frame to hold a line or cord, as, —

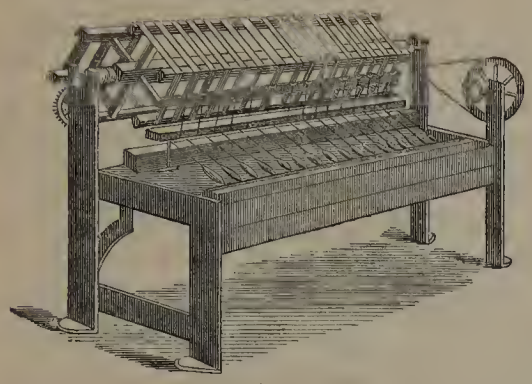
a. The *log-reel* or spool for the *log-line*. See LOG.

b. The *deep-sea* reel for the *deep-sea* lead-line of 150 or 200 fathoms. See SOUNDING.

c. The *spun-yarn* reel, etc.

5. (*Angling.*) A skeleton barrel attached to the

Fig. 4223.

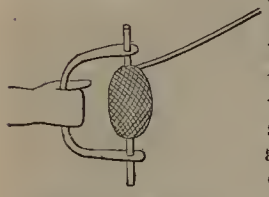


Reel for Cotton Yarns.

butt of an angler's rod, around which the inner end of the line is wound, and from which it is payed out as the fish runs off with the bait, and is gradually wound in again as his struggles become less violent, bringing him to land or to the landing-net. *A fishing-reel.*

The reel represented in the accompanying figure is from an ancient painting at Beni-Hassan, and was used for winding the cord by which the fish-spear or bident was recovered after throwing. In its construction it was merely a stirrup-shaped piece of metal, and a turning pin on which the cord was wound.

Fig. 4224.



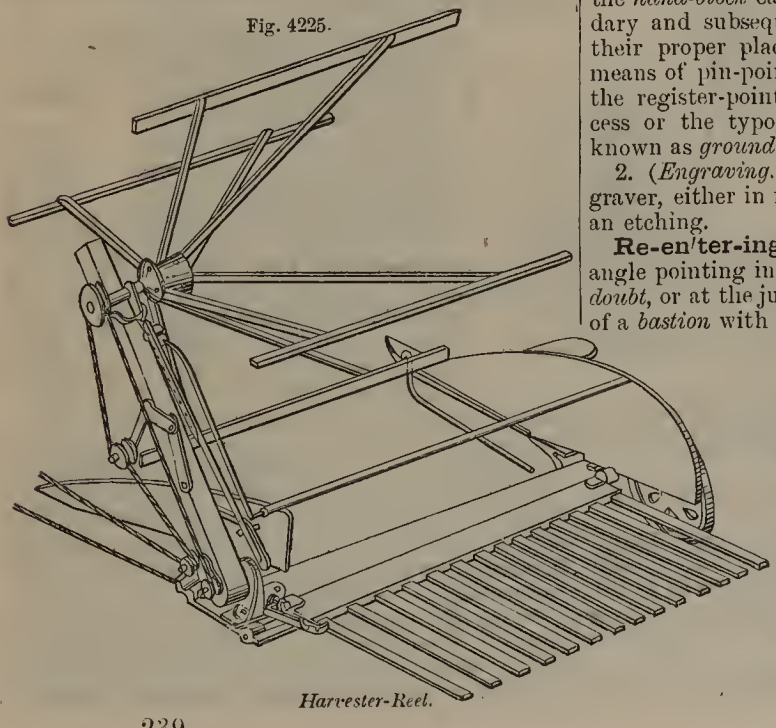
Egyptian Cord-Reel.

6. (*Telegraphy.*) A barrel on which the strip of paper for receiving the message is wound in a recording telegraph.

7. (*Oven.*) A cylinder with radial arms rotating in a heated chamber carrying pans in which loaves of bread are placed for baking in the *reel-oven.* See OVEN.

8. (*Milling.*) The barrel or drum on which the bolting cloth is fastened.

Fig. 4225.



Harvester-Reel.

9. (*Agriculture.*) A device having radial arms carrying horizontal slats, and rotated by gear or pulley connection with the axle of a harvester, for pressing backward and holding the stalks of grain in position for being severed by the knives.

The example shows the *reel* and the *dropper.* See REAPER, Plates XLIX., L.

Reel'ing-ma-chine'. (*Cotton-manufacture.*) *a.* A machine for winding the yarn off the bobbins of the spinning or twisting frames, and forming it into hanks or skeins. Fig. 4223.

b. A machine for winding thread on to reels or spools. See SPOOLING-MACHINE; SILK-REEL.

Reel-ov'en. A baker's oven in which the bread-pans are swung on the horizontal arms of a rotating reel.

The reel has a horizontal axis, which is rotated by gearing on the outside. To each arm of the reel — the number of the arms varying with the capacity of the oven — is a pendulous shelf or bread-pan. These at one part of their revolution are presented at an opening, through which the unbaked loaves are introduced, and thence pass downward toward the arch of the furnace. As each pan comes opposite to the opening it receives its load, and by the time all are filled the first one is again at the opening, the loaves baked and ready to be removed, clearing the pan for another batch. The baking is thus a continuous operation, the time of rotation of the reel being adapted to the completion of the process. In a later invention the pans, instead of being pendulous, are placed above the reel-arms, and the latter are preserved in horizontal position by pendulous weights beneath. See OVEN (Fig. 3444, page 1583).

Reem'ing. (*Shipbuilding.*) Opening the seams between planks for the insertion of new oakum.

The tool is a *reeming-iron* struck by a *reeming-beetle.*

Reem'ing-bee'tle. (*Shipbuilding.*) The larger mallet of the calker by which he drives the *reeming-iron.*

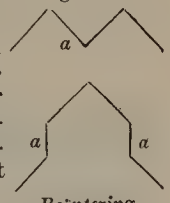
Reem'ing-i'ron. (*Shipbuilding.*) A sharp iron wedge used by calkers to force the planks apart temporarily, to admit the oakum.

Re-en'ter-ing. 1. (*Calico-printing.*) A term in the *hand-block* calico-printing applied to the secondary and subsequent colors, which are adapted to their proper place in the pattern on the cloth by means of pin-points. These are the equivalents of the register-points of the chromo-lithographic process or the typographic printing in colors. Also known as *grounding-in.*

2. (*Engraving.*) The deepening of lines by a graver, either in repairing a plate or for perfecting an etching.

Re-en'ter-ing-an'gle. (*Fortification, etc.*) An angle pointing inward (*a*), as in a *redoubt,* or at the junction of the *flanks* of a *bastion* with the *curtain.*

Fig. 4226.



Reintering-Angles.

Re-fin'er-y. An apparatus for removing impurities or crudities from metals, spirits, petroleum, sugar, and what not.

The term is a general one, and with metals may include *reducing*-furnaces of various kinds. Also *roasting, decarbonizing,* and *desulphurizing* furnaces, *Bessemer processes,* etc. (which see). See also MALLEABLE IRON, page 1378.

See also SUGAR-MACHINERY.

With liquors, the term includes apparatus and machinery for rectifying and ageing liquors.

With petroleum, it includes apparatus for removing the various crudities which are in the raw product.

Re-fin'ing. The process of freeing metals, liquids, or other substances from impurities or crudities which impair their quality or unfit them for their appropriate uses.

1. Liquids are, in some cases, refined by adding soluble substances which entangle the foreign matters, and sink to the bottom, as with wine and cider. This is termed *fining*. In other cases, the refining is by chemicals which combine with the impurities and form a precipitate.

Sometimes standing a length of time suffices to effect the separation, the supernatant liquid being decanted.

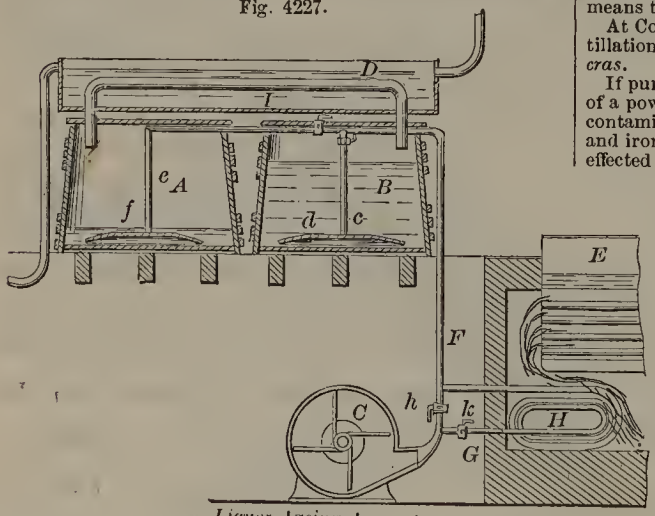
2. Saltpeter is refined by dissolving it in hot water until the water is saturated with salt. On cooling, the salt is deposited in a comparatively pure state.

3. Vinegar is refined by passing it through a filter to separate the mucilaginous matter. See RAPE.

4. Alcoholic spirits and liquids generally are refined by successive distillations. (See RECTIFICATION; STILL.) The same process is applicable to mercury, sulphur, and other substances, which may be volatilized at a high temperature and afterward condensed.

In one form of apparatus for refining and ageing liquors air from a blower *C* is heated in a coil *H* communicating with the pipe *F*, which has two branches *c c* extending downward through a disk near the bottom of the tubs *A B*. The liquor in the tub *B* is first heated to the temperature of 90°, and agitated by air passing from the coil *H* through the pipes *F c*, and rising from beneath the disk *d*, the cock *k* is closed and *h* opened, and cool air forced in through the pipe *F*. These processes are continued for the space of about a month, or until the desired result is

Fig. 4227.



Liquor-Ageing Apparatus.

attained. The air and alcoholic vapors pass over from *B* to *A* through the condensing-pipe *I* in the water-chamber *D*, the air being discharged from *A* through an aperture above.

5. Petroleum is refined by treatment with sulphuric acid and by distillation.

6. The process of cupellation (see CUPEL) is largely employed for refining silver. In this, lead, already in combination with or added to the silver, is oxidized by heat and absorbed in a porous cup, taking with it most of the other impurities which are not previously expelled by the heat.

7. Gold is refined by cupellation and by *parting*, that is, dissolving in nitric acid. See PARTING; GOLD.

8. Iron is refined in the furnace and by *puddling*. See IRON; REFINING-FURNACE; PUDDLING; BESSEMER-PROCESS.

Re-fin'ing-fur'nace. (*Metallurgy.*) The furnace in which metals undergo a process of purification and separation from the impurities with which they are usually contaminated, and are rendered fit for use in the arts. In some cases the metal is reduced from the ore and refined by one continuous operation; in others, two or more are required.

The art of refining gold, silver, iron, tin, and copper was practiced previous to times of which we have any authentic history, implements of bronze and copper and ornaments of the precious metals being found among other relics of the prehistoric age, both in the Old and New Worlds.

In ancient times, the precious metals were refined by successive reheatings.

"Silver tried in a furnace of earth, purified seven times."—Psalm xii. 6.

"They gather silver, and brass, and iron, and lead, and tin, into the midst of the furnace to blow the fire upon it, to melt it."—Ezekiel xxii. 20.

From the former of these passages we may infer that a high degree of purity was attained by seven successive refinings. Purifying the precious metals and then reducing their standard by means of alloying does not appear to have been generally practiced, and is not to this day in the East.

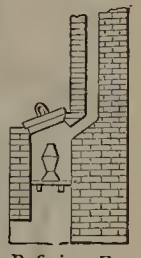
At Freiburg, Saxony, silver amalgamated by the barrel process is, after distillation, refined in crucibles, previously brought to a red heat. The silver is gradually introduced in lumps, and when fused strewn with powdered charcoal, and the crucible covered with an iron plate. After the lapse of a few minutes the impurities which had risen to the surface, together with the unconsumed charcoal, are skimmed off, more charcoal added, and the process repeated, occasionally stirring the molten metal, until its surface becomes bright and clean. When the process is complete, the silver should be malleable and dissolve completely in nitric acid. It is afterward cast into hemispherical ingots. The dust from the furnace flues is, after being sifted, mixed with and treated as ordinary silver ore. The slags and sweepings from the various melting operations are crushed and afterward fused with carbonate of soda and niter, by which means the silver is obtained in the metallic state.

At Constante, Spain, the porous silver obtained from the distillation of amalgam is melted in a species of cupola called a *cras*.

If pure, a loss of silver is entailed by exposing it to the action of a powerful blast; but if, as is generally the case, the metal is contaminated by impurities, such as lead, sulphur, antimony, and iron, which impair its malleability, their removal is readily effected by this apparatus.

Fig. 4228 is a section of a furnace for refining metals in pots. It is lined with the most refractory fire-brick, and has an opening of some 12 or 15 inches diameter, protected by a cover at top, through which the crucibles are introduced and the operation attended to. The grate-bars are removable, and, when required, an artificial blast is introduced beneath them by pipes.

Fig. 4228.



Refining-Furnace.

The operation of *refining* cast-iron consists in exposing it to heat and agents by which the carbon, silicon, and other extraneous matters are oxidized and removed. The pig-iron is either subjected to a preliminary purification in a *refining-furnace* or on a *hearth*, and the operation completed in a *puddling-furnace* (the English method), or it is effected in one operation in a puddling-furnace by an operation termed *boiling* (the American method). See PUDDLING.

When the operation is an intermediate one, the partially refined metal is run from the hearth into a bed, quenched with water, and broken with sledges to enable it to be handled into the puddling-furnace.

The bed of the refining-furnace is small, and the hollow boshes are of cast-iron, through which water flows, to resist the influence of the fire upon the sides of the chamber. Blasts of air are admitted through tuyeres, and the process consists in exposing the molten iron to the oxygen of the air, so as to burn away a part of the carbon and also remove certain noxious matters with which the iron is combined. The iron is then run into molds.

Lewis's refining reverberatory-furnace is thus worked. The fire of pitcoal is made on the grate bars, and when a melting heat is attained, the door of the iron-chamber is opened, and the basin occupying the middle of the floor is covered with a bushel of charcoal laid over a stratum of silicious sand, previously introduced. A bushel of hammer or forge cinder and then a ton of pig-metal is laid around the basin, which is about 10 inches deep, a space being left between the pigs so as to allow full access to the flame. The door of the iron-chamber is closed, and the fire pushed until the iron is about to melt. The iron is then dragged by a *rabble* into the basin, and the molten surface covered with a bushel of charcoal. The fire is kept up and the metal frequently stirred. When the decarbonization has proceeded to a sufficient degree, the metal is run off.

The consumption is said to be 15 to 18 bushels of pitcoal, 2 bushels of charcoal, making a ton of refined from 22 cwt. of pig metal.

The fluid iron from the blast-furnace is sometimes transferred direct to the refinery, thus saving the time and fuel required for remelting the pig-metal.

Various fluxes have been patented or proposed for assisting the process.

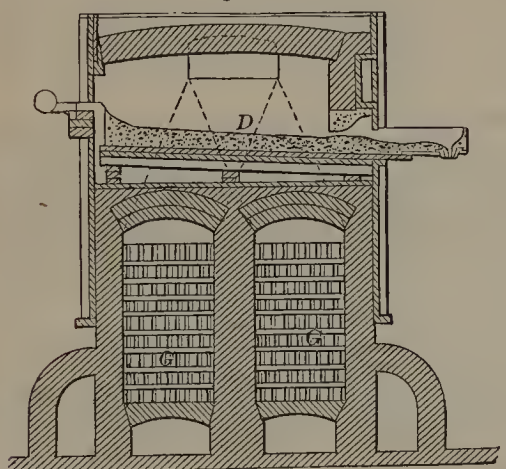
Hampton, 1856, slakes quicklime with a solution of alkali or alkaline salt. Du Motay and Fontaine use scoriæ from the puddling-furnace, oxides of iron and alkaline silicates or carbonates; Sanderson, 1855, uses substances containing oxygen or other element, by which silicium, aluminium, etc., are removed. Blackwell proposed remelting in a cupola furnace alone, or with the addition of substances containing nearly pure iron oxides.

Nasmyth and others have employed steam passed through or caused to impinge upon the molten metal in a state of ebullition.

Bessemer, in 1855, patented a process of this kind.

In Martin's furnace (French), pig-iron is fused and maintained at a temperature of 1,600° to 2,000° C. on the hearth *D* of a reverberatory-furnace having a

Fig. 4229.



Martin's Refining-Furnace.

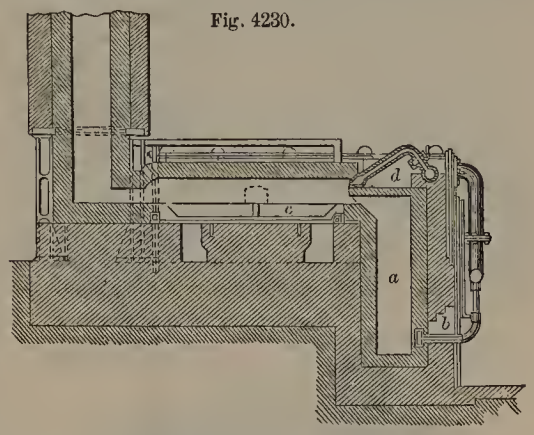
covering of refractory sand and heated by means of a Siemens regenerator *G G*. Ore, or puddled steel, or old iron in small pieces, is thrown in, and manganiferous iron afterward added.

At some of the Pittsburg iron-works the metal is refined by mechanically mingling pulverized oxides of iron with the molten crude metal direct from the blast-furnace. This is run from the furnace into a large kettle, and thence poured into a revolving circular trough. Pulverized ore from a hopper descends and covers the melted metal as fast as it runs into the trough, whose continuous rotation causes the formation of alternate thin layers of the crude metal and ore which combine to form malleable iron. Lake Superior, Champlain, or Iron Mountain ore is employed.

Chlorine, hydrogen, and coal gas, the oxides of manganese and zinc, etc., have also been employed.

In Eck's furnace (German), coal gas is used. A quantity of coal is introduced into the generator *a* through an opening in the bottom, and when this has become fully ignited the opening is bricked up and the generator filled with coal from above; a moderate supply of air to support combustion is allowed to enter through the lower tuyeres *b*. When the refining-hearth *c* has become thoroughly dried and heated, about 40 cwt. of iron

Fig. 4230.



Gas Reverberatory-Furnace.

is distributed over the hearth, so as to expose as much surface as possible to the action of the flame. The fusion of the charge is effected in about three hours, the gas generator being always kept filled and the supply of air from the lower tuyeres diminished after each introduction of fresh coal, as the latter yields its gas more freely at first.

Air introduced through the upper tuyeres *d* effects the combustion of the gas as it passes from the generator on to the hearth. During the progress of fusion the metal is shifted, so that each part may in turn become exposed to the hottest portion of the blast, in the vicinity of the fire bridge.

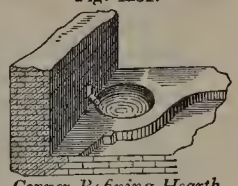
When all the iron is fused, about five pounds of limestone are thrown over its surface, in order to convert the dross into fusible slag.

The blast from two side tuyeres is now directed upon the fused metal, blowing aside the slag and creating currents in the mass, so that a fresh surface is continually exposed: the operation is assisted by stirring with an iron rod, and fresh limestone occasionally added. the total amount used being about 1 per cent of the crude metal.

The iron is withdrawn through a tap-hole at the side of the furnace, the opposite tuyere being employed to aid in forcing it out. The duration of the treatment after fusion varies from 2½ to 5 hours, the latter time being required to produce pure white iron.

Re-fin'ing-hearth. The copper-refining hearth has a hemispherical crucible of about 16 inches diameter, and lined with a puddle of 2 parts charcoal, 1 part clay. It is partly surrounded by a raised border, the open portion of which has a door to prevent the escape of the fuel. The lining is renewed before each operation, and is burnt on by a fire ignited in the crucible before charging with the fresh charcoal and pieces of black copper. The blast being let on and the copper fused, metal and fuel are added from time to time, the scoriæ being let off by a side-channel.

Fig. 4231.



Copper-Refining Hearth.

Sulphurous acid escapes and other volatile ingredients, if present. When the operation is complete the workman stops the blast, throws water on the hearth, rakes back the scoriæ with his *rabble*, and throws water on the metal, which congeals a thick film on the surface; this is of a red color, and is known as a *rosette*, the metal being *rose-copper*, and obtained by successive *quenching* and removal of the *rosettes*.

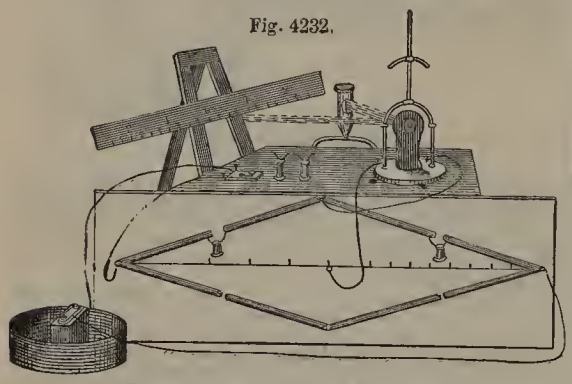
A farther refining, to reduce the suboxide of copper and obtain malleable metal, is conducted in a crucible covered with small charcoal and placed in a hearth similar to the foregoing.

Re-flect'ing-cir'cle. (*Optics.*) An instrument for measuring altitudes and angular distances, invented by Mayer about 1744, and afterward improved by Borda and Troughton.

In principle and construction it is similar to the SEXTANT (which see), the graduations, however, being continued completely round the limb of the circle. Troughton's has three arms radiating from the center at angular distances of 120° apart, each provided with a vernier, so that each angle measured is derived from the mean of three readings at opposite points of the arc, which tends to correct errors of centering and graduation. See REPEATING-CIRCLE.

Re-flect'ing-gal'va-nom'e-ter. Sir William Thomson's reflecting-galvanometer consists of a very small magnet, made of a piece of watch-spring, suspended between two flat bobbins of fine insulated copper wire. The magnet carries a very small con-

Fig. 4232.



Thomson's Reflecting-Galvanometer.

cave mirror, which is adjusted by means of a directing-magnet to throw the rays of light issuing from a lamp and reflected from the mirror upon the zero of a horizontal graduated scale when no current is passing or when two equal and opposite currents neutralize each other. In any other case the vibrations of the magnet cause the image to be deflected to the right or left of zero by an amount proportional to the force and duration of the current.

The figure shows the instrument employed in determining resistances in connection with Wheatstone's *bridge*.

Re-flect'ing-lev'el. The reflecting-level represents the object as reflected upon a long surface of water in an inverted position. Invented by Mariotti.

Another kind consists of a polished metallic mirror, placed at a small distance before the object-glass of a telescope, suspended perpendicularly. This mirror being set at an angle of 45°, the perpendicular line of the telescope will become a horizontal line, that is, a line of level. Invented by Cassini. See LEVEL.

Re-flect'ing-mi'cro-scope. A form of microscope first proposed by Newton, in which the image formed by a small concave speculum may be viewed either by the naked eye or through an eye-piece. Owing to the difficulty of illuminating the object, it was long disused, but has been revived by Professor Amici, who places the object outside of the tube of the microscope, and reflects its image to the speculum by means of a plane mirror, inclined at an angle of 45° to the axis of the former.

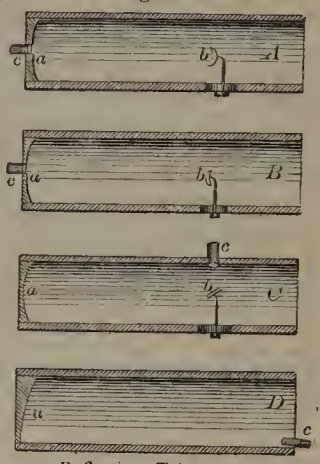
Re-flect'ing-tel'e-scope. A telescope in which the rays are received upon an object-mirror and conveyed to a focus, at which the image is viewed by an eye-piece.

There are four principal varieties: —

A Gregorian.
B Cassegrainian
C Newtonian.
D Herschelian.

The Gregorian telescope (*A*, Fig. 4233) was invented by Gregory, and described by him in his *Optica Promota*, 1663.

Fig. 4233.



Reflecting-Telescopes.

The object-mirror is perforated in the axis, and the rays of light, being reflected from the surface of *a*, cross each other in the focus, where they form an inverted image, and are then intercepted by a small concave mirror *b*, which causes them again to converge to a focus, where they form a direct image viewed by the eye-piece *c*, screwed into the tube behind *a*.

The Cassegrainian telescope (*B*) differs from the Gregorian in having the small mirror *b* convex, but not sufficiently so to render the rays reflected from *a* divergent; they are therefore brought to a focus just in front of the large speculum, forming an inverted image which is viewed by the eye-tube.

In the Newtonian form (*C*), invented by Sir Isaac Newton, 1669, the rays falling on the concave speculum *a* are intercepted before being converged to a focus by the small plane mirror *b*, placed diagonally in the main tube, which reflects the image to the eye-piece inserted in the side of the tube. The small mirror *b* may be caused to approach or recede from the large speculum by means of a sliding device on which the wire supporting it is mounted.

In the Herschelian or front-view telescope (*D*), the open end of the tube is directed toward the object to which the observer turns his back. The small mirror is dispensed with, the image formed by the large mirror being viewed directly through the eye-piece. Less light is lost by this arrangement than where two mirrors are employed.

Re-flect'or. 1. (*Optics.*) A device by which the rays proceeding from a luminous or a heated object are thrown back or diverted in a given direction. A mirror. The latter term, however, appears to be less comprehensive, being usually only applied to such surfaces as afford definite images and colors, while a reflector may not merely be used for throwing back the rays of light and heat, or of heat only, but also the waves of sound.

The reflecting surface may be either plane or curved. In practice it is often made spherical or parabolic. The former does not bring the rays to a true focus, but is easily formed, and is consequently generally employed where extreme accuracy is not sought for.

"The surfaces formed by the revolution of the ellipse, parabola, and hyperbola are such that the first accurately reflects diverged rays to a focus, the second parallel rays, and the third divergent rays." — BRANDE.

The material should be as smooth and highly polished as possible. Sheet-tin is frequently used for common purposes, as for door or hall lamps, or those carried by vehicles, while for other purposes a more perfectly reflecting surface is employed, such as speculum metal or silver protected by glass. See SILVERING; PLATINIZING.

Silver is the most perfectly reflecting substance known, absorbing but 9 per cent of the incident rays, while speculum metal absorbs 37 per cent. Glass itself, owing to its property of totally reflect-

ing incident rays at a low angle, is used in certain cases.

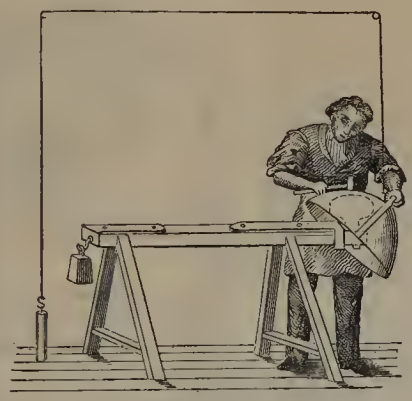
Reflectors with parabolic surfaces are employed for throwing the light emanating from objects placed in their foci in parallel straight lines to a great distance, and for converging the heat rays from a distant object, as the sun, to a focus, and also, in connection with eye-glasses, in the reflecting-telescope, which is itself often simply denominated a reflector. See REFLECTING-TELESCOPE; CATOPTRIC LIGHT; MIRROR; BURNING-GLASS.

The reflectors used with microscopes are various, according to the exigencies of the position, shortness of the focus, etc.

Under ILLUMINATOR are cited *Beck's, white-cloud, side-reflector, parabolic reflector, Lieberkuhn*, etc., — all forms of reflectors adapted to microscopes.

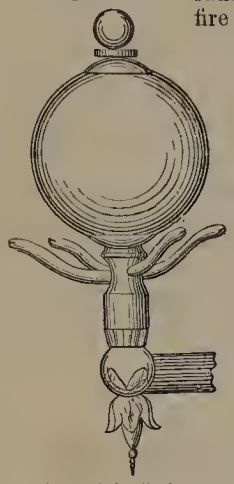
Paraboloidal reflectors were employed in the lighthouses at Bidstone and Hoylake, at the entrance of the Mersey, as early as 1763. These were of wood lined with mirror glass; smaller ones of tin were also employed. At present, lighthouse reflectors are made of copper heavily plated with silver. The proper curve is imparted by heating with mallets and hammers of various forms and materials; a hezel is formed around the rim, which is afterward stiffened by a metallic strap, and the interior surface polished with powder. Two ingots of pure silver and copper, of equal surface, weighing respectively 6 and 16 ounces, are tied together with wire, a flux of burnt borax and niter applied, and the ingots placed in a furnace. By repeated reheatings, rolling, and annealing, a plate 28 inches square is formed, which is then cut into a circular disk. A slight convexity is then formed at the back by beating with a round-faced boxwood mallet. The silvered side of the plate is placed on a slightly concave beechwood block and beaten from the edge gradually toward the center. The partially rounded disk is then placed concave side downward on a rounded steel former mounted on a horse, and beaten first with the peen and afterward with the face of the mallet until the proper form and size are nearly attained; it is next planished and afterward smoothed with a light hammer muffled with parchment at each end. To facilitate handling, the reflector is slung in a flexible frame counterbalanced by a weight suspended from a cord passing over pulleys. It is finally finished by carefully beating up all depressions, the accuracy of the work being continually tested by a gage or templet.

Fig. 4231.



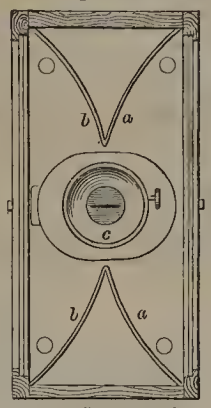
Reflector-Making.

Fig. 4235. radiating the heat from an open fire into an apartment.



Gas-Light Reflector.

Fig. 4236.



Street-Car Lamp-Reflectors.

Fig. 4235 is a reflector for workshop and household purposes. It has a globular polished surface, so that the light of the several gas-jets by which it is surrounded may be equally diffused on every side.

Murch's reflector for lamps of street cars has a pair of parabolic reflectors *a a*, *b b*, joined at their apexes, where a portion of each is removed. At this central position, which is approximately at the foci of the reflectors, is a lamp *c*, whose beams are thus thrown in both directions in nearly horizontal beams of limited lateral divergence.

2. A short name for the REFLECTING-TELESCOPE (which see).

3. The reflector has also been extensively used for Dr. Franklin and Count Rumford appear to have been the first who put forward intelligent ideas on this subject.

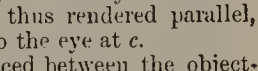
As early as 1795, a patent was taken out in England for a removable reflector, and in 1805, polished metallic reflectors were placed on each side of the fireplace, to be turned at any angle to reflect the heat of the fireplace into the room. In 1816, the fire-grate was inclosed in a hollow metallic globe opening in front of the grate. In 1852, the hearth, cheeks, and faces of the grate were made of polished steel. Several devices for radiating heat were patented in this year.

Sylvester's invention for this purpose is described as follows: The hearth is formed of a framework of hollow radiating metallic bars, diverging and fanlike in arrangement, upon the farthest end of which the fuel is supported. The air for combustion passes through the hollow bars to the fire, which also derives a supply in front in the usual way. The ends of the bars on which the fuel rests become intensely hot. The remaining portion or hearth from conduction becomes likewise heated, and radiates its warmth around. The fire, being situated upon the hearth, allows the greatest possible length of surface to the cheeks or sides of the stove, which are of polished metal, and contribute greatly to the amount of heat afforded by radiation. The smoke escapes through the apertures of a kind of louver at the back, and the ashes pass between the bars into a receptacle beneath.

Re-fract'ing-tel'e-scope. A telescope in which the rays are refracted by an object-glass, at whose focus they are viewed by an eye-piece. It is the ordinary form of telescope. See TELESCOPE; ASTRONOMICAL TELESCOPE; EQUATORIAL, TERRESTRIAL REFRACTING-TELESCOPE, etc.

The original form of the telescope, as used by Galileo, had a convex object-glass and a concave eye-glass.

Fig. 4237.



Galilean Telescope.

The rays converged by the object-glass *a* fall upon the double concave lens *b*, which intercepts them before they arrive at the principal focus, where they would make an inverted image. Being thus rendered parallel, they give a distinct vision to the eye at *c*.

The lens *b* is therefore placed between the object-glass and the image, and at a distance from the image equal to its principal focal distance. The magnifying power is equal to the focal length of the object-glass divided by the focal length of the eye-glass.

Re-frac'tion-cir'cle. (*Optics.*) The refraction-circle of the Washington Observatory was made by Ertel and Son, of Munich. The telescope has a clear aperture of 7 inches, and is 8½ feet in length. It is supported in the middle of the axis between two piers, and it has two circles of 4 feet diameter, one on each end of the axis, divided on gold into arcs of

2′. Each circle is provided with six reading microscopes. See also TRANSIT-CIRCLE.

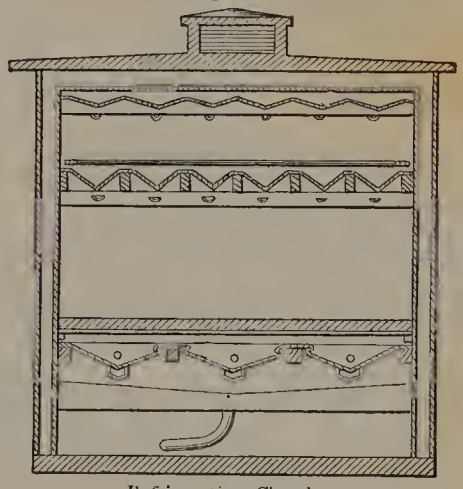
Re-frac′tor. A refracting-telescope. See TELESCOPE.

Re-frac′to-ry. (*Pottery.*) A piece of ware covered with a vaporable flux and placed in a kiln, to communicate a glaze to the other articles; an operation termed *smearing*.

Re-frig′er-at′ing-cham′ber. An apartment for the storage of perishable provisions during warm weather. It is frequently a structure in connection with an ice-house.

In the example, the ice is stored overhead and the meat or vegetables in the larger room beneath. The cool air descends by gravity and displaces the moist and warmer air, which

Fig. 4238.



Refrigerating-Chamber.

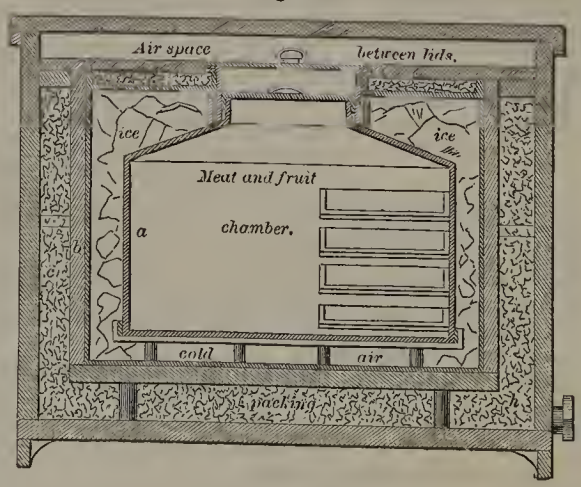
ascends. The moisture condenses upon the ceilings of the meat-chamber and the ice-chamber, which are formed of angularly corrugated metallic plates; and the drip from the salient angles is caught in troughs, by which the liquid is conveyed to the exit-pipe.

Re-frig′er-a′tor. Refrigeration, natural or artificial, is used for keeping animal or vegetable substances by reducing the temperature below the point of fermentative disorganization. Such are fruit and meat cellars and cars.

Wort, mash, or beer coolers are of this class; also apparatus for reducing the temperature of the *must* of wine, the juice of sugar-cane or beets.

Saccharine juices and wines may be concentrated to a certain extent by freezing: the watery particles becoming congealed are removed, leaving the remainder of a greater strength.

Fig. 4241.



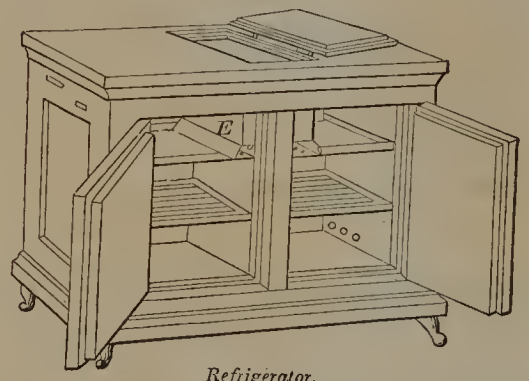
Allegretti's Refrigerator.
(Section.)

1. A *refrigerator* for cooling wort consists of a large shallow vat traversed by a continuous pipe, through which a stream of cold water is passed. The *wort* runs in one direction and the water in the other, so that the delivery end of the wort is exposed to the coolest part of the stream of water. See also LIQUID-COOLER; BEER-COOLER.

2. (*Steam.*) *a.* A casing with connecting-tubes, through which feed-water passes on its way to the boiler, and is warmed by the current of hot brine passing in the other direction, on the outside of the tubes. The hot brine, at a temperature of say 218° Fah., is that which has been removed from the boiler by the *brine-pump*. The term *refrigerator* is a misnomer. It should be called a *feed-water heater*. The latter name is applied to a somewhat similar arrangement in which the feed-water is heated by exhaust steam.

b. The chamber in one form of condenser, in which the injection-water (fresh) is cooled by a surface application of cold sea-water. See INJECTION-CONDENSER.

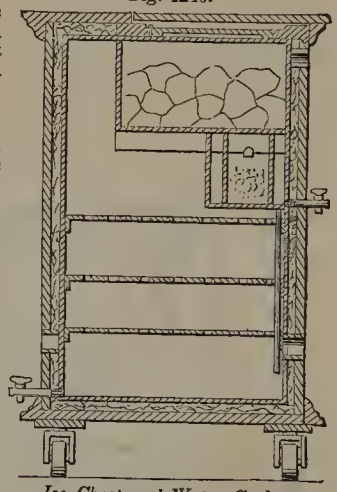
Fig. 4239.



Refrigerator.

3. (*Domestic.*) A chest or closet holding a supply of ice to cool provisions and keep them from spoiling in warm weather. In the example, a vertical channel divides the refrigerator into two separate chambers, each partitioned into three receptacles. Air circulates between the interior and exterior walls. Two front doors and one on top afford access. *E* is the ice-box, which cools the air in each of the side chambers.

Fig. 4240.



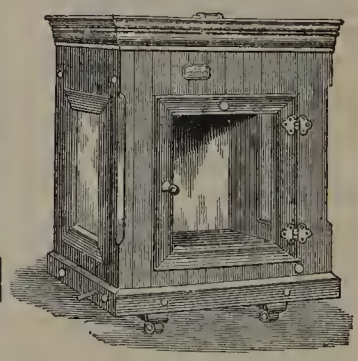
Ice-Chest and Water-Cooler.

Fig. 4240 shows a chest whose melting ice passes through a filter into a chamber, whence it is drawn as ice-water. Drip and water of condensation are withdrawn at the lower faucet.

Figs. 4241, 4242, are respectively a sectional interior view and an exterior perspective view of the Allegretti refrigerator, which has an inner metallic chamber *a* for containing the articles to be preserved, and an outer inclosing case *b*, with a packing of non-conducting material *c* around it to preserve the ice from being melted by access of heat to it. The inner and outer cases are so arranged that there shall be ice-chamber or space above and around, and cold-air space below the inner chamber. A close, tight frame is made around the opening to the inner chamber, to admit access thereto without exposing the ice or cold-air space to the external air. A pipe *h* carries off the water of liquefaction from the ice.

When it is desired to produce a very

Fig. 4242.



Allegretti's Refrigerator.
(Perspective View.)

intense degree of cold, chemicals are added to the ice. In most cases it is desirable to maintain a constant temperature of about 32° Fah., so as not to disorganize the tissues of the meat or vegetables. The even temperature, neither too high nor too low, is necessary to produce the best results; with a temperature of 32° Fah. meat will ripen but remain perfectly fresh for any length of time, being much better than when fresh killed.

Fig. 4242 shows the refrigerator with double glass door and double glass panel in the side.

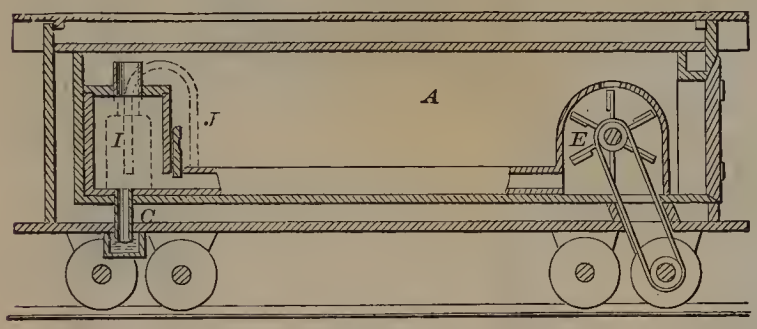
This machine will permit the experiment of transporting fish at a point just above the freezing, in which animation seems to be suspended, they remaining perfectly inert whether in or out of water.

The apparatus is also cordially recommended to the scientific successors of Professor John Meiser, of Dantzic, and Dr Martout, of Fontainebleau, when another such subject as Colonel Fougas shall be available. See Edmond About's "The Man with the Broken Ear."

Re-frig'er-a'tor-car. (*Railway.*) A car through which a current of artificially cooled air is caused to circulate, for the purpose of preserving meats, game, etc., during their transportation over long lines of rail.

The experiment of constructing cars specially for this purpose was first tried in 1867, and was successful; meat slaughtered in Illinois being delivered in sweet and fresh condition at New York ten days thereafter, during the hottest part of the summer.

Fig. 4243.



Refrigerator-Car.

In Fig. 4243, the refrigerating chamber *A* is surrounded by an air-space. Air is forced by the blower *E* into the chamber through an ice-box *I*, which may contain a case in which is a freezing mixture, in this case passing through the pipe *J*. The water is drawn off by a trap *C*.

The external appearance of one of these cars is similar to that of an ordinary freight-car. In a box at each end of the car are blocks of ice placed on a grate in such a manner as to allow a current of cold air to circulate constantly through a flue near the top of the car, over the ice, down to the floor, then up among the poultry, mutton, and beef, and again around through the flue and over the ice. The circulation of air is effected by a large ventilator-wheel placed horizontally at the top of the car near the middle. The forward movement of the car keeps this wheel in motion, which, in turn, produces a current of cold air constantly from the ice to the meat in one direction, and from the meat to the ice in another direction. By this means, every piece of meat is kept at a uniform temperature of about 40° Fah. The cars are built double all around, with inside double doors, filled in with charcoal, and have a capacity for holding two tons of ice. At the principal stations they are carefully examined, and ice added whenever it is deemed necessary.

Re-frig'er-a-to-ry. A chamber, vessel, or pipe, in which a cooling is effected, as, —

1. The worm of a still. See STILL.

2. (*Steam-engine.*) *a.* The condenser of an engine. See CONDENSER.

b. A form of heater in which feed-water extracts a portion of heat from the hot water driven out of the boiler by the brine-pump.

3. The worm or chamber of a liquid-cooler for beer, wort, wash, etc. See LIQUID-COOLER; BEER-COOLER.

4. The chamber in which ice is artificially formed. See ICE-MAKING MACHINE.

5. (*Domestic.*) The chamber in which provisions are kept by exposure to a cool atmosphere. See PRESERVING FOOD; REFRIGERATOR; ICE-CHEST; ICE-SAFE, etc.

Re-fus'al. (*Hydraulic Engineering.*) The resistance to farther driving offered by a pile. For instance, the refusal of a pile intended to support 15½ tons may be taken at 10 blows of a ram of 1,350 pounds, falling 12 feet and depressing the pile .8 of an inch at each stroke.

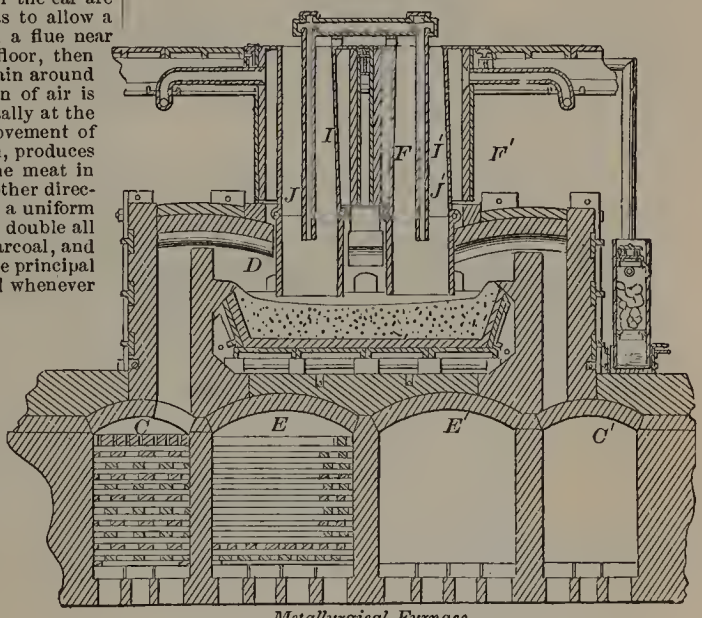
Re-gen'er-at'ing-fur'nace. A furnace in which the outgoing heated volatile products are caused to heat a mass of material, which, when the direction of the current is reversed, heats the incoming air or gas with which the furnace is supplied.

In Siemens's apparatus both heated vapor, or vapor and steam, and atmospheric air are passed through the regenerators and consumed in the furnace. It has of late been extensively employed for glass, pottery, and metal-reducing furnaces, and in the production of steel, either directly from the ore or from iron.

Fig. 4244 illustrates an apparatus particularly designed for making steel from the ore. *C C'*, *E' E'*, are the regenerators. These are filled in with fire-brick, so laid as to leave a large number of passages between them, through which the air or gas may circulate on its passage to and from the furnace.

Heated gas from the *producer*, a furnace in which gases are generated by the combustion of coal, and into which steam may be injected to form hydrogen gas by its decomposition, passes through a pipe to the generator *C* at the same time that a current of hot air is passing through the generator *E*. These are conducted to the furnace *D* by pipes *J J'* in the cylinders *I I'*, through which the mixed ores, charcoal, and flux, if any, are introduced. A quantity of pig-metal is placed in the bottom of the furnace, and the reduced ore from the cylinders *I I'* is forced downward and mixed with it, and spiegeleisen added if required. The mingled air and gas, having effected the work of reduction, pass out through the generators *C' E'*, and are conducted away to the chimney. Chambers *F'* on either side of the furnace also communicate with it and with the chimney. When the generators have become heated to a thoroughly white heat, the current are, by means of a reversing valve, diverted so as to flow in the opposite direction, entering through the generators *C' E'* and passing out through *C E*. The products of combustion are thus alternately heated by each set, and cooled by the other, to which they impart their heat, so that when discharged

Fig. 4244.



Metallurgical Furnace.

into the chimney they are at a comparatively low temperature

Re-gen'er-a-tor. A device to abstract the head from an escaping volume of air or gas, in order that it may be imparted to a body of incoming air. The object is economy of fuel by conservation of heat.

An illustration of this may be found in the air-engine of Glazebrook, English patent, 1797, and in Stirling's English patent, 1816. The latter had the metallic sieves of wire gauze afterward adopted by Ericsson. Their use in this connection is a fallacy. See AIR-ENGINE. See also REGENERATING-FURNACE.

Reg'is-ter. 1. A device for automatically indicating the number of revolutions made or amount of work done by machinery, or recording steam, air, or water pressure, or other data, by means of apparatus deriving motion from the object or objects whose force, distance, velocity, direction, elevation, or numerical amount it is desired to ascertain.

There are various special appliances of this kind, each particularly adapted for the peculiar operation which is to be investigated; many depending on the action of clock-work mechanism, which indicates results on dials, but others, as in registering meteorological instruments, having means for recording varying conditions, as with the *anemometer*, *barograph*, etc.

As counters, are the various devices known as ARITHMOMETERS (which see). These, in their primary intention as calculating instruments, are not mere registers, but they are attached to other devices to keep count of motions, and so become *registers* or *recorders*. Instances may be found in the recording devices of

Billiard-registers.
Counting-registers.
Furnace-registers.
Granary-registers.
Measuring-registers.
Passenger-registers.
Printing-press registers.
Speed-recorders.
Steam-engine registers.
Street-car registers.
Telegraph-registers.
Time-registers.
Ventilation-registers.
Watchman's registers.
Weighing-registers

See also list under METERS.

The device so common in arithmometers, calculating-machines, and registers, consisting of a series of wheels numbered 0 to 9, and gearing into each other, so as respectively to represent units, tens, hundreds, etc., was invented by Pascal when 19 years of age (1650).

Among the applications of gearing to produce extremely slow motions which may be utilized in counting, and are, therefore, applicable to registers, may be cited epicyclic and differential gears.

Fig. 4245.

Differential Counter.

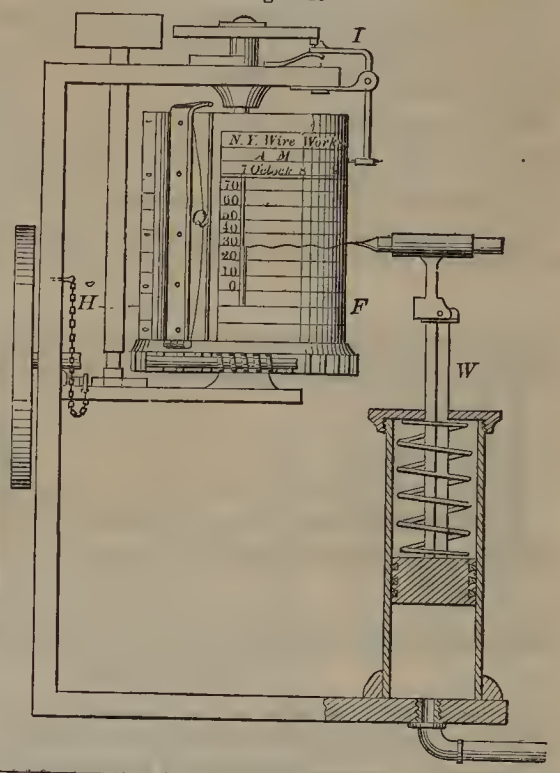
The matter as to the former has been considered at as full a length as admissible under EPICYCLIC TRAINS (which see).

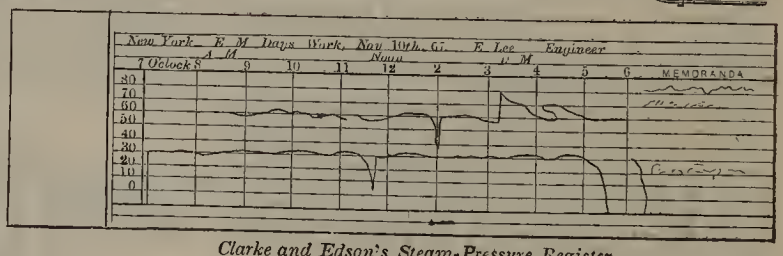
A differential device is shown in Fig. 4245. Two worm-wheels of equal diameter (teeth omitted in the illustration) have respectively 100 and 101 teeth, and are in gear with the same worm. One wheel gains 1 revolution over the other during 10,100 revolutions of the worm. Each wheel has an index-finger, and the angular distance between them on a graduated dial will form a register.

Watt first applied a *register* to the steam-engine to count the strokes.

The term *register* is also applied to a *recording indicator* (see INDICATOR), as in the example (Fig. 4246), in which an endless roll of paper wound on to the upright cylinder *F* and held thereto by a pad *Q* is uniformly drawn off therefrom by the roller *H* rotated by connection with the engine. Clock-work mechanism causes a point at the lower end of the lever *I* to puncture the paper at hourly intervals. The paper being previously ruled with vertical hour-lines with intervals corresponding to a given rate of speed, the relation of the punctures to these lines indicates whether the engine has been run at the proper velocity. The rate of pressure is recorded by a marker on the piston-rod *W* of a cylinder connected by a pipe with the steam-chest. For this purpose horizontal lines corresponding to different pressures are ruled on the cylinder.

Fig. 4246.





Clarke and Edson's Steam-Pressure Register.

The rolling-mills in the United States Mint at Philadelphia are provided with dials having a hand indicating the exact distance between the rolls. It is the invention of Franklin Peale. A crank on the arbor of the index-hand is the means of adjusting the *set* of the rolls, and certain points on the graduated dial indicate the distance for half-dimes, dimes, quarters, gold dollars, eagles, and all the varieties of coin which are made at the mint. The process of rolling is called *breaking down*, and the ultimate size is obtained by repeated rolling, perhaps ten times for gold and eight times for silver. The register is set to a certain mark for each thickness, to which the bar is reduced during the successive rollings.

2. (*Printing.*) Agreement of two printed forms to be applied to the same sheet, either on the same or the respective sides thereof.

The former is used in chromatic printing, where a number of colors are laid on consecutively.

The latter is found in book and newspaper printing, where the correspondence of pages or columns on the respective sides is required.

The registering apparatus of the printing-press consists of points which pass through the paper and serve as guides for relaying the paper on the tympan in printing a second color, or as guides in folding.

3. (*Heating.*) A sliding plate acting as a damper or valve to close or open an aperture for the passage of air. As, —

a. The draft-regulating plate of a stove or furnace. Sometimes connected with a pivoted plate in the chimney, so as to be self-operating. The damper-plate of a locomotive engine.

b. A perforated plate governing the opening into a duct which admits warm air into a room for heat, or fresh air for ventilation, or which allows foul air to escape.

Savot in his work "L'Architecture François des Bastimens particuliers," Paris, 1624, is the first to mention the *register-plate*. He credits the invention to the English, saying that it is customary in England when a brazier full of fuel is well lighted, and has ceased to smoke, to pass an iron plate (*porte de fer legère*) across the chimney, and so confine the heat to the room. This plate is the same as the *damper*, but the term *register* is the older.

In the furnaces of the alchemists, openings left for the supply of air, and which could be contracted or closed by pieces of clay, were termed *registers*.

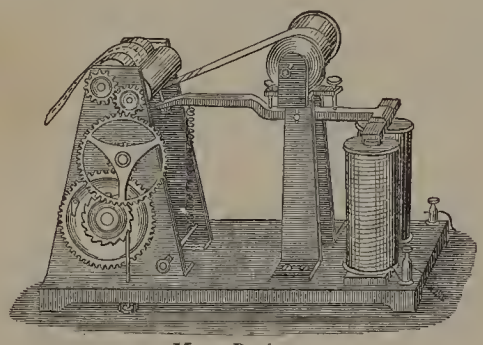
Ben Jonson says: —

"Look well to the register,
And let your heat still lessen by degrees."

4. (*Music.*) A stop of an organ.

5. (*Telegraphy.*) The part of a telegraph apparatus used for recording upon a strip of paper the message received. It consists of a clock-work, which moves the strip of paper at a uniform speed in contiguity to the *stylus* or marking-pen, whose movements are controlled by the electrical current. In the ordinary Morse apparatus this stylus is simply a sharp metallic point on the end of the armature lever, which embosses the character on the strip of paper on being brought in contact therewith.

Fig. 4247.

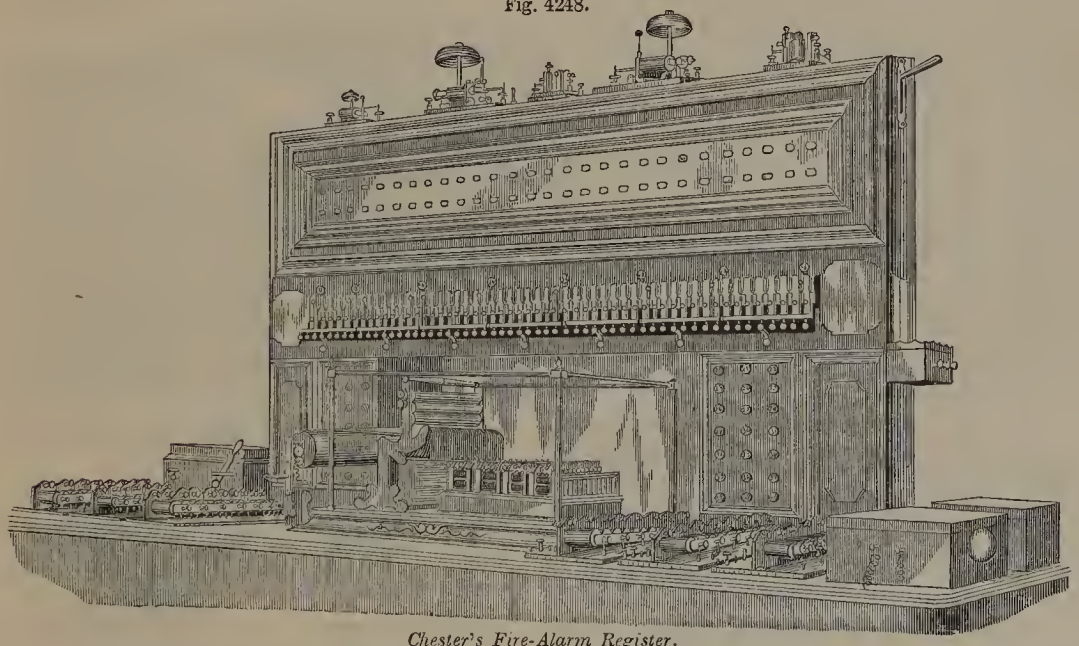


Morse Register.

An inking stylus or an inking roller is sometimes used in lieu of a plain stylus.

The fire-alarm telegraph register records all the alarms and tests which are sent into the central office. The line currents from the stations are received through a series of fifty-six relay magnets, which also act upon annunciators indicating the number of the station turned in.

Fig. 4248.

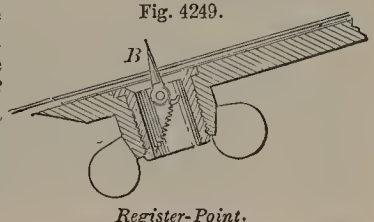


Chester's Fire-Alarm Register.

When a signal is struck at a street box the circuit is broken, the magnet appropriate to that station drops, operating a lever which throws down the annunciator corresponding to that number, rings a bell, sets in motion the register train, carrying forward a broad, endless roll of paper, and by means of a pen, of which there are fifty-six, actuated by as many magnets, imprints the signal on the endless roll. The condition of the line is also hourly tested through this apparatus.

Reg'is-ter-point. (*Printing.*) A device for puncturing or holding a sheet of paper, serving as a guide in laying on the sheet, so that the impressions on each side shall accurately correspond or *register* correctly. One is placed on each side of the table. In the example, the pivoted pointers *B* are snapped by a spring into the sheet and hold it in position till the nippers of the cyl-

Fig. 4249.



Register-Point.

inder draw the sheet, when the point automatically retires.

Reg'is-ter-ing-ther-mom'e-ter. A thermometer in which the column of mercury moves a glass or porcelain bar and leaves it at the maximum or minimum point which is reached by it between observations. See THERMOMETER; MAXIMUM THERMOMETER; MINIMUM THERMOMETER.

Reg'let. 1. (*Printing.*) A strip of wood or metal with parallel sides and of the hight of a *quadrat*, and used for separating pages in the chase, etc.

They are sometimes made type-high to form black borders.

2. (*Architecture.*) A flat, narrow molding, employed to separate panels or other members; or to form knots, frets, and similar ornaments.

Reg'let-plane. A plane used in making reglets or printer's furniture for spacing lines. The adjustable *fences* are screwed fast to the body of the plane, and project from the sole a distance equal to the hight of a *quadrat*, so that when the fences rest on the bench the plane-bit will cut no longer. See cut under ROUNDING-PLANE.

Re-grat'ing. (*Masonry.*) Taking off the surface of an old hewn-stone wall in order to whiten it and make it look fresh again.

Reg'u-la. (*Architecture.*) A band below the tænia of the Doric epistylium, extending the width of the triglyph, and having six guttæ depending from it. It also signifies the space between two adjoining canals of the triglyphs.

Reg'u-lat'ing-screw. A screw used for determining a motion.

The motion of the roller of a copperplate press, upward from the bed, is regulated by screws which bear upon the journal-boxes.

The upper roll of a bar, sheet, or other iron mill is similarly arranged.

The motions of the slides and moving parts of machinery are sometimes regulated by screws, which act as *stops* or *slides*.

Reg'u-la'tor. A mechanical contrivance for equalizing motion.

The generic name may be held to include *governors, thermostats, gas-regulators, fly-wheels, flyers, dampers, pendulums, balance-wheels, throttle-valves, compensation arrangements in timepieces*, etc. These will be found under their specific heads.

1. The brake-band of a crab or crane.

2. (*Steam-engine.*) *a.* The governor of a steam-engine. See GOVERNOR.

b. The *cataract* of a steam-engine. See CATARACT.

c. A device for admitting steam in regulatable quantity to the valve-chamber of the steam-cylinder. See REGULATOR-BOX.

3. (*Furnace.*) A device for regulating access of air to a stove or furnace. Known as a *draft-regulator*. It may consist of a *register*, *damper*, or *door*. Automatic appliances actuated by the variations of heat are THERMOSTATS (which see).

4. (*Horology.*) *a.* A clock keeping accurate time, used for regulating other timepieces.

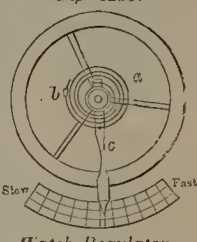
b. The device by which the pendulum-bob is elevated or depressed.

c. The fly of the striking part of a clock or musical box.

d. An arm which determines the length of the balance (or hair) spring of a watch. By shortening the length of spring involved in the action, the rate of motion is increased, and conversely. On the under side of the arm are two pins, which embrace the spring, the center of motion of the arm being concentric with the arbor of the balance. As the arm is rotated, the pins slip on the spring, the extent of movement of the arm being indicated by a pointer on a graduated arc.

The balance-spring *a* is attached at its outer end to a stud *b* on the watch-plate, and at its inner end to the staff of the balance. The balance pulsates in one direction under the influence of the main-spring communicated through the train, and is returned by the recoil of the spring after passing the point at which these forces are in equilibrio. The duration of the pulsation is determined by the length of the hair-spring *a*, a longer spring allowing a longer movement of the balance. The lever *c* has two curb-pins, between which the hair-spring passes, and its activity is checked at this point. By moving the lever to the right, the effective length of the spring is decreased, and the pulsations are shortened, the balance moving quicker. When the watch is *too* fast, motion in the other direction corrects it.

Fig. 4250.

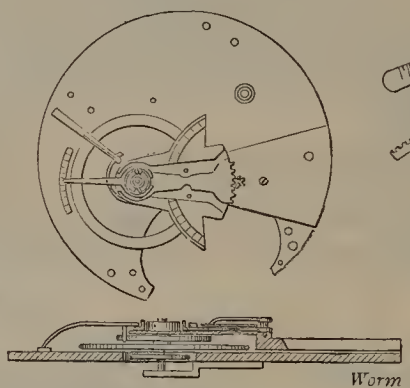


Watch-Regulator.

Means have been employed for the more delicate adjustment of this arm, other than by a mere push. Among these are the worm-wheel and rack, as in Fig. 4252.

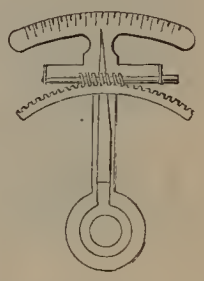
In Fig. 4251, the pointer which carries the pins embracing the hair-spring is connected to a bar having a segmental rack, actuated by a small cog-wheel; the shaft of the latter carries a pointer, by moving which a delicate adjustment is obtained.

Fig. 4251.



Watch-Regulator.

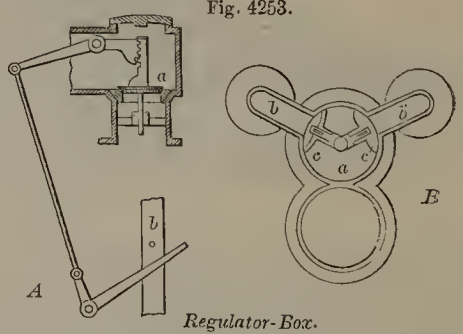
Fig. 4252.



Worm Wheel Adjustment for Regulator.

Reg'u-la'tor-box. A valve-motion contrived by Watt for his double-action, condensing pumping-engines (*A*). A spindle passes through one side of the box, on which a toothed sector moves as a center, working a rack fixed to a brass valve *a*, which is accurately ground to its seat. The plug-tree *b* is provided with a pin which trips the lever, whose upper arm is connected to the toothed sector, so that the reciprocations of the plug-tree open and shut the valve.

Fig. 4253.



Regulator-Box.

In locomotives (see *B*) a pipe conducts steam from the steam-drum to the regulator *a* connected with the cylinders by two pipes *b b'*, which are opened or closed by the valves *c c'*, operated by a rod running longitudinally of the engine and turned by a lever within reach of the engineer.

The *regulator-cock* admits oil or tallow for lubricating the faces of the regulator.

Reg'u-lus. (*Metallurgy.*) The relatively pure metal which sinks to the bottom of a crucible or a furnace in the fusing and refining process. The slag or scoriæ floats upon it, and is skimmed off or conducted in another direction.

The term is not now often used, except when applied to antimony.

Re-heat'ing-fur'nace. (*Metallurgy.*) A reverberatory-furnace, resembling a puddling-furnace, in which blooms or piles of sheared or scrap iron are reheated for rolling or rerolling. A *balling-furnace.*

Rein. 1. (*Saddlery.*) A strap or cord by which a horse is driven or controlled. The ends of the rein are fastened to the bit-rings, as, —

Driving-rein.	Check-rein.
Bearing-rein.	Gag-rein.
Safety-rein.	Overhead-rein.

The Scythians hung the scalps of their enemies to their bridle-reins. The Red Indians do the same. Attila is similarly represented.

The Japanese bridle-rein is often of silk.

2. (*Architecture.*) A *springer* or lower *voussoir* of an arch, which rests upon the *imposts.*

3. A rope of twisted and greased raw-hide.

Reins. The handles of a blacksmith's tongs, on which the ring or *coupler* slides.

Re-in-force'. An additional thickness imparted to any portion of an object in order to strengthen it, as, —

1. (*Ordnance.*) The enlarged portion of a cannon, extending from the *base ring* to the *chase.* It is formed in casting, or by shrinking on a band of metal.

The *first reinforce* is that nearest the breech, where the metal is thickest.

The *second reinforce* extends from the termination of the first to a point forward of the *trunnions.* These distinctions are obliterated in American guns of the later patterns.

The *Armstrong gun* (English) is built up of coils and reinforces around a steel tube.

2. A strengthening patch. (See PATCH.) It may be an additional thickness sewed around a cringle or eyelet-hole in a sail or tent-cover; a piece pasted around the buttonhole of a paper collar, etc.

3. A patch on a tube, boiler, tank, etc.

Re-in-force'-ring. (*Ordnance.*) A flat molding at the breech end of the reinforce.

Rein-hold'er. (*Menage.*) A clip or clasp on the dashboard of a carriage, to hold the reins when the driver has alighted.

Rein-hook. (*Harness.*) A hook on a gig-saddle to hold the bearing-rein.

Fig. 4254.

Check-Rein Hook.

Rein-slide. (*Harness.*) A slipping loop on an extensible rein, which holds the two parts together near the buckle, which is adjustable on the standing part.

Fig. 4255.

Rein-Snap.

Rein-snap. (*Harness.*) A spring hook for holding the reins. In the example, one spring *c* retains the ring in the hook, and the other, *d*, forms a mousing to keep anything from accidental engagement with the point of the hook. See also SNAP-HOOK; HARNESS-SNAP.

Reis'ner-work. Inlaid work on the principle of the BUHL (which see). Reisner was a skillful practitioner of the art about the time of Louis XIV. He principally used woods of contrasted colors, while Buhl used metals and tortoise-shell by preference.

Imitations of this and buhl are now made by stamping instead of cutting out with the saw. At Birmingham, devices are stamped from sheet-brass and applied to papier-maché, the intervening depressions being filled up with successive coatings of black Japan varnish. See also BUHL; MARQUETRY; PARQUETRY; INLAYING, etc.

Re-joint'ing. (*Masonry.*) Pointing, as of walls.

Re-lay'. (*Telegraphy.*) A subsidiary electro-magnetic circuit made and broken by the primary circuit. By means of the relay-magnet, a current too feeble to produce sensible mechanical effects at a distance is made to set in action an auxiliary current competent for the work. Invented by Professor Joseph Henry. — PRESCOTT, *History of the Electric Telegraph.*

Re-lay'-mag'net. (*Telegraphy.*) A small electro-magnet requiring but a weak current to charge it, and having an armature to which is attached a lever ending in a platinum point, which impinges against a back stop whenever the armature is attracted by the electro-magnet. This back stop and armature form part of the circuit of a local battery to the sounder or register. If the main-line current arriving at an office is too weak to work the sounder or register, the relay is placed in the main circuit and operates to close a local circuit to the sounder or register whenever its armature lever is attracted against its back stop. This device, indispensable on long lines of telegraph, was invented by Professor Henry. See MORSE INSTRUMENT.

Re-lief'. 1. (*Sculpture.*) The prominence of a sculptured figure from the plane surface to which it is attached. According to the degree of prominence, it is known as *alto* or *high relief*, *mezzo* or *demi-relief*, and *basso* or *low relief.* See RILIEVO.

2. (*Fortification.*) The total hight of the parapet above the bottom of the ditch.

Re-lief'-line En-grav'ing. The process of Mr. Palmer of England, about 1840, in which a blackened copper plate is covered with a ground of a definite thickness of sulphate of lead, wax, and resin; a tracing or photographic image is transferred to the *ground;* the ground is cut away by gravers or etching-points, so as to make lines down to the metallic surface, which is blackened so as to enable the effect of the work to be seen. The plate then receives a coating of graphite, and an electro-cast is made, forming a raised surface from which to print.

The hight of the little ridges in the cameo cast in copper is equal to the depth of the ground through which the design was cut. In the broad spaces — the lights, where the lines are at a considerable distance apart and there is a danger of ink attaching itself to the plate in inking — wax is dropped upon the ground before *blacklead*ing, so as to make elevations at those points which become depressions in the electro-cast.

This process was adopted by Jewett and Chandler of Buffalo for many years in making the cuts for the Patent Office reports, and is still practiced by Mr. Chandler in making the cuts forming the illustrations of this Dictionary and numerous other works.

Re-lief'-pro'cess. See PHOTO-RELIEF PROCESS.

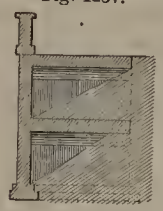
Re-lief'-valve. 1. (*Steam-engine.*) A valve belonging to the feeding apparatus of a marine-engine, through which the water escapes into the hot-well when it is shut off from the boiler.

Fig. 4256.

Relief-Valve for Beer-Engine Pipes.

2. A valve so arranged as to open outward when a dangerous pressure or shock occurs, to allow escape of water.

Fig. 4257.



Relieving-Arches.

3. A valve to allow access of air to a barrel from which liquor is drawn.

Re-liev'ing-arch. An arch at the back of a revetment or retaining wall, to relieve the pressure of the bank upon the wall, and act as a tie or interior buttress. Arches of this description have their axes and the faces of their piers at right angles to the face of the bank. The front end is usually closed by a vertical wall. The arches of two stories are shown in section, with the retaining wall, and a talus of soil occupying a part of the space beneath each.

Re-liev'ing-tack'le. (*Nautical.*) *a.* A tackle temporarily attached to the end of the tiller, to assist the helmsman in bad weather, and act as a guard in case of accident to the tiller ropes or wheel.

b. A tackle from a wharf passed beneath a vessel when careened, and secured to the opposite side, to act as a guard against upsetting and to assist in righting.

Rel'ish. (*Joinery.*) The projection of the shoulder of a tenoned piece beyond the part which enters the mortise. See TENON.

Rem'berge. (*Vessel.*) A long, narrow, low rowing vessel of war, formerly used by the English.

Rem'blai. (*Fortification.*) The elevated portion of earthworks formed by the disposition of the *déblai*, or excavated materials.

Rem'e-dy. (*Coining.*) The allowance at the mint for deviation from the exact standard fineness and weight of coin. In England the *remedy of the mint* is: Gold, 12 grains per pound in weight; $\frac{1}{16}$ of a carat in fineness. Silver, 1 dwt. per pound in weight; 1 dwt. per pound in fineness. Copper, $\frac{1}{40}$ of the weight, both in weight and fineness.

The remedy of United States gold coin is, double-eagle, one half grain; smaller gold coins, one quarter grain.

On coin in bulk, $\frac{1}{1000}$ of an ounce in 5,000 gold pieces of the denominations $20, $10, $5, $2.50; $\frac{1}{1000}$ of an ounce in 1,000 gold pieces of the values $3 and $1.

The remedy on United States silver coin is $1\frac{1}{2}$ grains to the piece. Or, on coin in bulk, $\frac{3}{1000}$ of an ounce in 1,000 silver pieces of the values $1, 50 c., 25 c.; $\frac{1}{1000}$ of an ounce on 1,000 dimes. On the minor coins, 3 grains for the 5-cent piece; 2 grains for the 3 and 1 cent pieces.

Re-mon'toir. (*Horology.*) A mechanism designed to render the force which sustains the movement of the escapement perfectly even.

Re-mon'toir-es-cape'ment. An escapement in which the scape-wheel is driven by a small weight raised by the clock at intervals of thirty seconds, usually; or by a spiral spring on the scape-wheel arbor, wound up a quarter or half turn at the said intervals.

Rem'o-ra. (*Surgical.*) An instrument to retain parts in place; as one to keep the intestines from protruding at the inguinal ring after the operation of castrating, or one to maintain a fracture in place or a luxation reduced.

Ren'der. 1. (*Nautical.*) To pass through the block; said of a rope. To *reeve*. To *rack* a tackle is to seize the parts together and prevent *rendering*.

2. To try out lard or tallow.

Ren'der-ing. 1. (*Plastering.*) The first coat of plaster on brick-work. It is followed by the *floating* coat and the *setting* coat, the latter of *fine* stuff.

The first coat is sometimes termed the *pricking-up* coat. When on lath it is said to be laid. *Rendered* and *set* is complete two-coat work on brick or stone.

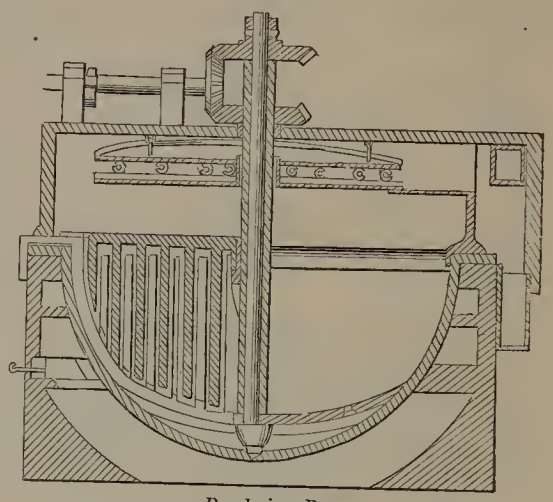
2. The process of trying out oil or lard from fat. See RENDERING-APPARATUS; LARD-TANK.

Ren'der-ing-ap'pa-ra'tus. An apparatus for extracting oil and lard from fatty animal matters. The object to be attained is to separate the purely oleaginous part from the cellular tissue inclosing it. In household economy this is effected by simply heating the fat, previously cut into small pieces, in an open vessel over the fire; this separates the greater part of the purely oily matter. The scraps, called *cracklings*, are freed from the remainder by straining and pressure.

Somewhat more complicated arrangements are introduced when the process is conducted on a large scale, in order to more perfectly extract the oily matter with economy of labor and material.

Black's apparatus consists of a pan set in a furnace, which has two flues, the lower one communicating with the fireplace by means of apertures,

Fig. 4258.

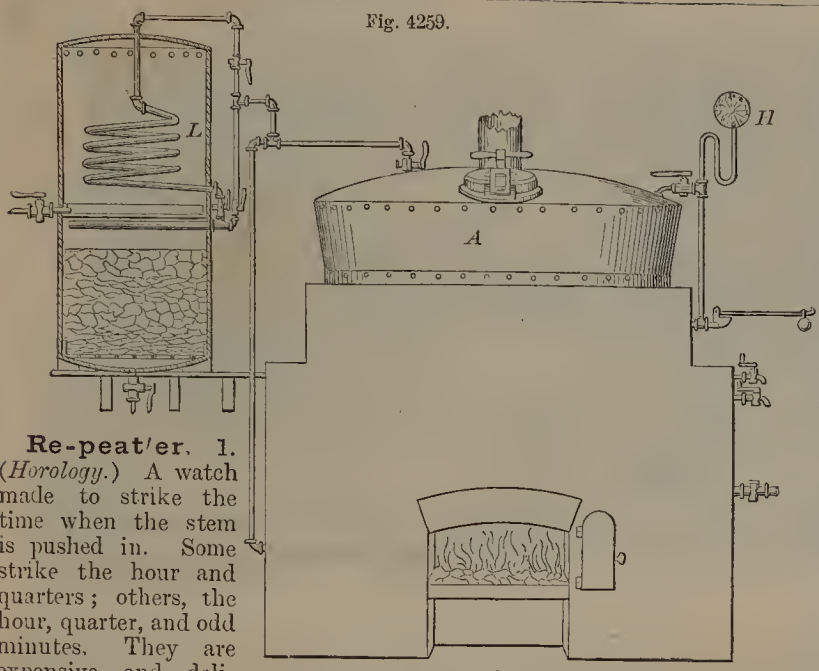


Rendering-Pan.

which may be closed when desired by dampers. The pan has a perforated false bottom, and in the space between the bottom and false bottom is arranged a rotary stirrer. Above the false bottom is a hollow rotary shaft provided with arms. The pan has a tight cover, to which are suspended two plates, the upper one being provided with gutters. The interior of the pan communicates with a condenser which is connected with a drain or sewer. The vapors are condensed by means of cold water supplied by perforated boxes.

Gray's apparatus (Fig. 4259) consists of a closed tank or kettle *A* having a jacket covering the part which comes in contact with the fire. The space contains water, which is heated so as to render the lard in the kettle. The vapors and gases which escape from the lard during the process of rendering are carried through a coil *L* in a condenser, and afterward through a gas-purifier, or they may be conducted into the furnace and burner. A gage *H* indicates the amount of steam-pressure; try-cocks at different hights are provided for drawing off the lard in a fluid state. See also LARD-BOILER; LARD-TANK.

Fig. 4259.



Rendering-Apparatus.

Re-peat'er. 1. (*Horology.*) A watch made to strike the time when the stem is pushed in. Some strike the hour and quarters; others, the hour, quarter, and odd minutes. They are expensive and delicate, owing to the assemblage of so many parts within so limited a space.

Some *repeaters*, in addition to their announcement of the hour when called on, will strike the hours and quarters as they recur. A *striking* watch merely has not the faculty for *repeating* when called on so to do.

Alarms are also attached to watches. The machinery is somewhat similar to that of the alarm-clock.

James II., in person, heard arguments on interfering applications for patents for repeating-watches (Barlow *vs.* Quare), and decided in favor of Quare (1676). Priority of invention belonged, however, to Barlow, who employed two pins to strike the hours and quarters, while Quare afterward effected this with one only.

The smallest repeating-watch ever known was made by Arnold for George III., to whom it was presented on his birthday, June 4, 1764. Although less than six tenths of an inch in diameter, it repeated the hours, quarters, and half-quarters, and contained the first ruby cylinder ever made. Its weight was that of an English silver sixpence. Arnold made it himself, and also the tools employed in its construction. The king presented Arnold with 500 guineas ($2,500) for this curious watch, and the Emperor of Russia afterward offered the maker 1,000 guineas for a duplicate of it, which Arnold declined.

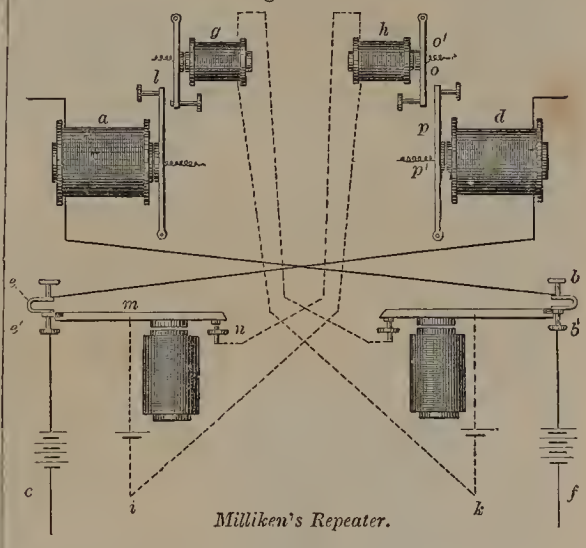
2. (*Fire-arms.*) An arm which may be caused to fire several successive shots without reloading. In Colt's and other revolvers, the charges are placed in chambers in a rotating cylinder, and brought successively in line with the barrel; while in the Spencer, Winchester, and Henry rifles, and others of that class, a number of the cartridges are inserted in a chamber at the butt or beneath the barrel, and fed and discharged singly by mechanism connected with the lock devices; metallic cartridges only are employed, the case being automatically ejected after each discharge. See FIRE-ARMS; REVOLVER.

3. (*Telegraphy.*) An instrument for automatically resending a telegraphic message at an intermediate point, when, by reason of length of circuit, defective insulation, etc., the original line current becomes too enfeebled to transmit intelligible signals through the whole circuit. The original circuit being divided into two or more shorter circuits, the sounder or armature lever of one circuit opens and closes another circuit by an action similar to that of a *relay*.

Fig. 4260 is a plan of Milliken's. The main-line wire from one direction (west, for example) passes through the relay-magnet *a* and the repeating points *b b'* of the opposite sounder, and thence to the battery and ground at *f*; the eastern line passes through *d*, *e e'*, and to *c*.

The extra local magnets *g h* are so arranged that when either of their armatures is released, it is drawn back by the spring attached to its lever, bringing the latter firmly in contact with the armature lever of the corresponding relay. The dotted lines show the circuits from the extra local batteries at *i k*. If the main circuit be broken in the western wire, the relay *a* breaks the local circuit in the sounder at *l*. The movement of the lever *m* of the sounder first breaks the extra local circuit at *n*, causing the magnet *h* to release the armature *o* which is drawn back by the spring *o'* against the top of the lever *p*, and the eastern main circuit is also broken at *e e'*. The lever *p* is prevented from falling back when the circuit of *d* is broken by the tension of the spring *o'*, which is so adjusted as to be greater than that of the spring *p'*. The apparatus on the right-hand side of the repeater therefore remains quiet while the west is working, and *vice versa;* the current through *d* being always restored

Fig. 4260.

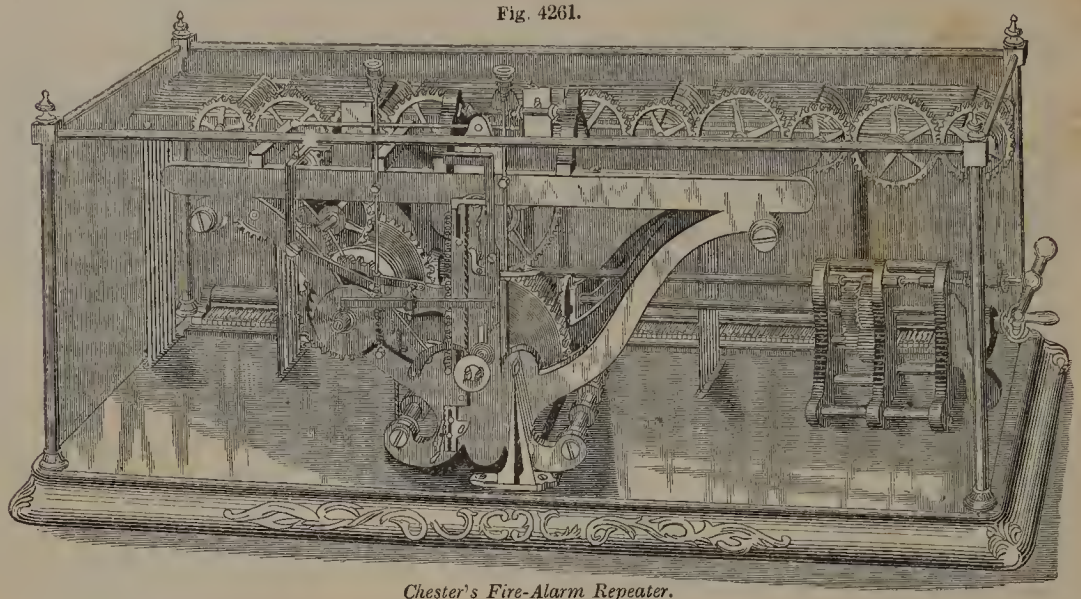


Milliken's Repeater.

before that through *h* is broken, which is effected by the U-shaped spring on the screw *e*.

Fig. 4261 is a fire-alarm telegraph-repeater. It has a series of large broad-faced circuit-wheels having teeth, in sets of 8, arranged spirally on its periphery. These are faced with platinum, and as the wheels are revolved by clock-work and weight, make contact with springs also armed with platinum and arranged in sets of 8, throwing the current into the line wires to the different stations in order, or to such of them as the operator may desire. Those not wanted are thrown out of circuit by a switch-board. Numerical signals from 1 to 998 may be transmitted. In order that these may be repeated automatically, a series of toothed regulating-wheels, so arranged as to be readily attached or detached, is provided. Each of these has only the teeth corresponding to the particular signal which it represents, and when placed in the train the current is not transmitted through the current-wheels by the springs which make the circuit through it and the circuit-wheels, when the interspaces between the omitted teeth are out of contact with the springs. The times in which these and the circuit-wheels make a revolution are automatically adjusted, so that equal intervals shall elapse between the striking of each tap of the signal, which denotes the units, tens, or hundreds, as the case may be; the

Fig. 4261.



Chester's Fire-Alarm Repeater.

gearing then ensures a complete revolution of the circuit-wheel; the remaining part of the signal, if it consists of more than one place of figures, is struck in a similar way, and the operation is continuously repeated until the regulator-wheel is displaced.

Re-peat'ing-cir'cle. A reflecting-instrument, on the principle of the sextant, for measuring angular distances. The image of one of the observed objects, after being reflected from a mirror on a pivoted arm and again from a fixed mirror, is brought into coincidence with the other seen by direct vision; the *apparent* angular distance is thus doubled, and the graduations of the circle, which are continued all the way around its limb, thus embrace 720° of arc.

It was first invented by Mayer about 1744. Borda, after whom it is frequently called, in 1780, introduced a second arm and vernier, to which Troughton subsequently added a third.

The mean of the readings given by each arm is taken as the true angular measurement, which may be repeated continuously around the circle, bringing a different part of the limb into use at each repetition, thus tending to eliminate errors of centering and graduation.

Notwithstanding the accuracy theoretically obtainable by this principle, there appears to be, says Sir John Herschel, some constant source of error in this instrument which in a large degree counterbalances its theoretical advantages. It has consequently never come into extensive use either in this country or England. See REFLECTING-CIRCLE; SEXTANT; QUADRANT.

Re-peat'ing Fire-arm. One which discharges several successive shots without reloading.

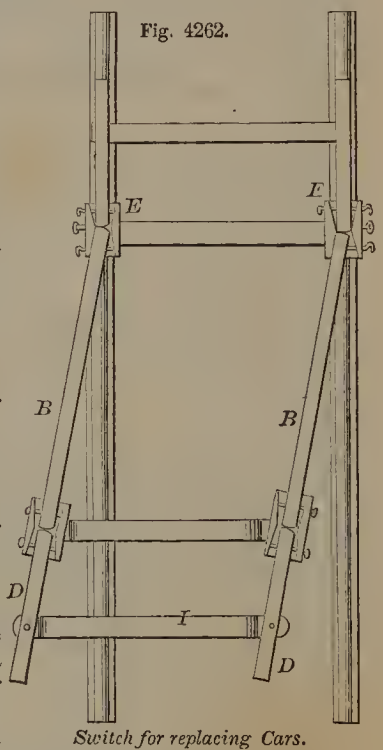
"After dinner was brought to Sir W. Compton a gun to discharge seven times, the best of all devices that ever I saw, and very serviceable, and not a bawble; for it is much approved of, and many thereof made." — PEPYS's *Diary*, 1662.

In the armory of the Tower of London are several Indian pieces known to be as old as the fifteenth century, and in principle similar to our revolvers. They have the defect of liability to ignite all the charges at once, and were abandoned as dangerous and useless. Specimens of British and French manufacture are in the museums of England and France; and the fire-arms of Collier, an American gunsmith, 1818, and of another American in 1819, have the defects of their predecessors. Colonel Colt is believed to be the first inventor of a really available repeating pistol. (TEMPLE.) His first device was a number of barrels, but he subsequently devised the rotating cylinder breech and single barrel. See also MAGAZINE FIRE-ARM; REVOLVER.

Re-peat'ing-watch. (*Horology.*) One constructed to strike the hours and quarters when the stem is pushed in. See REPEATER.

Re-plac'ing-switch. A device forming a bridge by which the wheels of cars are replaced upon the track. A section is laid upon each track, and has a shoe *E* to which an inclined piece *B* is jointed. The inclined section rests upon another shoe. *D I* are farther extension-pieces which are pushed in below the wheels.

Fig. 4262.



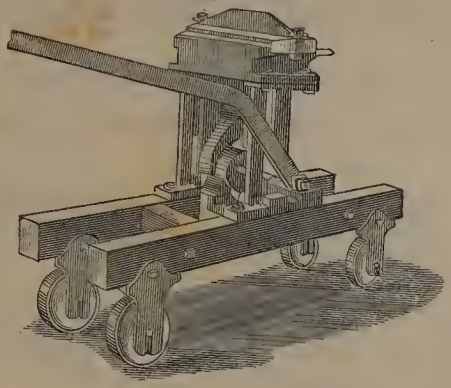
Switch for replacing Cars.

Re-pous-sé'-work. A kind of chasing. It is effected entirely by the hammer. The workman uses a plain flat sheet of silver, having before him a model of the article to be produced. The plate rests upon a soft bed of pitch or other composition, and with a small hammer the workman produces indentations on the inner surface of the plate, corresponding to the design. A small steel punch is, in some cases, employed; and if the relief is accidentally made too high, it is reduced by counter hammering.

Benvenuto Cellini, 1500–70, is celebrated in this and kindred branches of the arts.

Re-press'ing-ma-chine'. A machine for repressing brick after being partially dried. Also used for making brick direct from the clay, in warm climates, where brick are used without burning;

Fig. 4263.

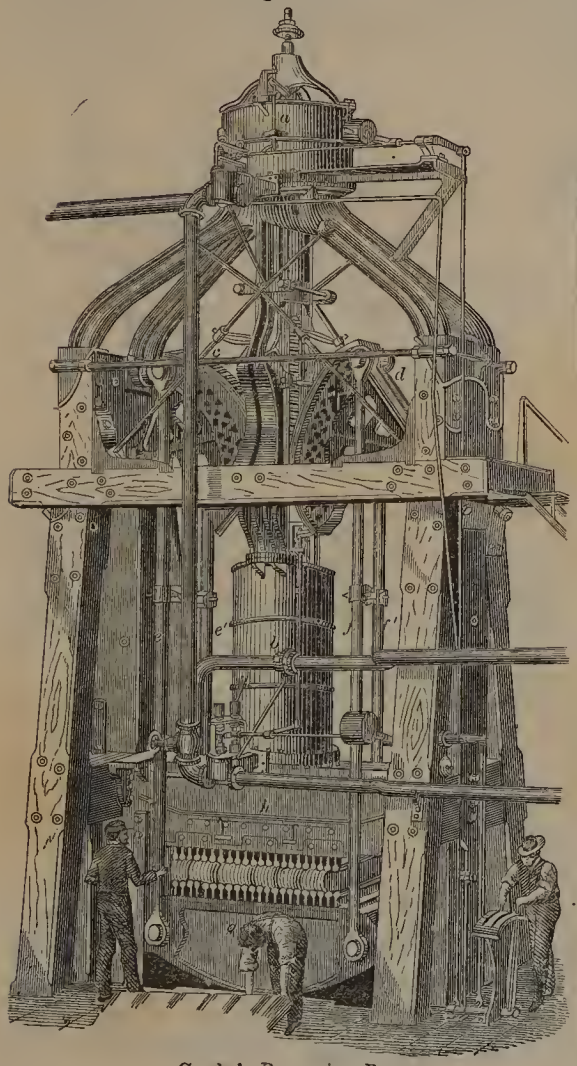


Repressing-Machine.

adobes. In that illustrated, the brick is placed within the mold, the sliding cover which had been pushed aside for that purpose being replaced, the lever is depressed, raising a platen forming the bottom of the mold; on throwing up the lever the reverse movement of the eccentric allows the platen to descend a certain distance, the sliding cover is slipped aside, and a farther upward movement of the lever causes the platen to rise sufficiently to permit the brick to be removed.

Re-press'ing-press. A press designed for compacting bales of cotton, etc., into the smallest possible compass for transportation. Grader's (Fig. 4264) has two steam-cylinders *a b*, the upper one of which is of greater diameter than the lower. The piston of the lower has a ratchet which engages with the toothed arcs *c d*, to whose upper extremities are attached rods *e e' f f'* connected with the platen *g*. Steam admitted below the lower piston causes an upward movement of the segments, which, through the medium of the rods *e e' f f'*, raise the platen and compress the bales placed between it and the immovable bed *h*. If a greater pressure is desired than is thus obtainable, the piston of the large cylinder *a* is caused to descend; a clutch on its piston-rod then engages the teeth on the ratcheted piston-rod of the lower cylinder, and on admitting steam below the upper piston a farther upward movement is imparted to the platen *g* through the medium of the ratchet, arcs, and connecting-rods.

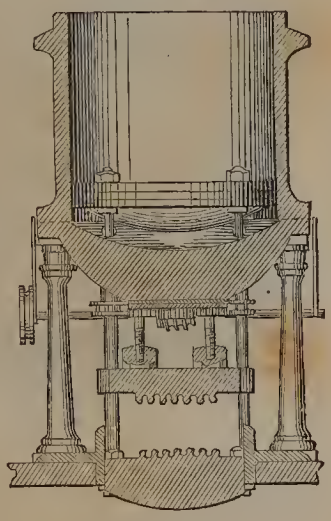
Fig. 4264.



Grader's Repressing-Press.

The power of the press may be varied, — by using the lower cylinder alone; by working the upper cylinder expansively; by working the upper cylinder expansively and the lower under full boiler pressure; and by using full boiler pressure in both cylinders.

Fig. 4265.

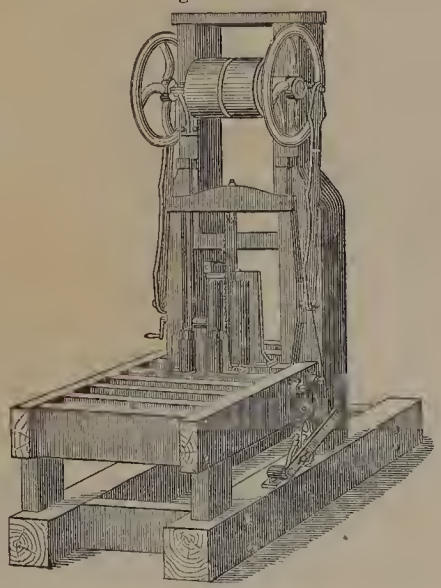


Repressing-Press.

The repressing-press may be of any suitable form and construction, but the steam or hydraulic form shown in Fig. 4265 is compact and effective.

Rere'dos. 1. (*Architecture.*) The wall at the back of an altar or seat. In Gothic churches it is usually in the form of a screen detached from the eastern wall, and is ornamented with niches, statues, etc., paintings, or tapestry. Fine examples occur at Durham and St. Albans, England.

Fig. 4266.



Resawing Machine.

2. A projecting buttress on the back of a fire-place, or a movable plate occupying a similar position. It is called a *fire-back*, and its office is to throw forward the fire, so that it may radiate into the room. Hollinshed calls it a *rere-dorse*.

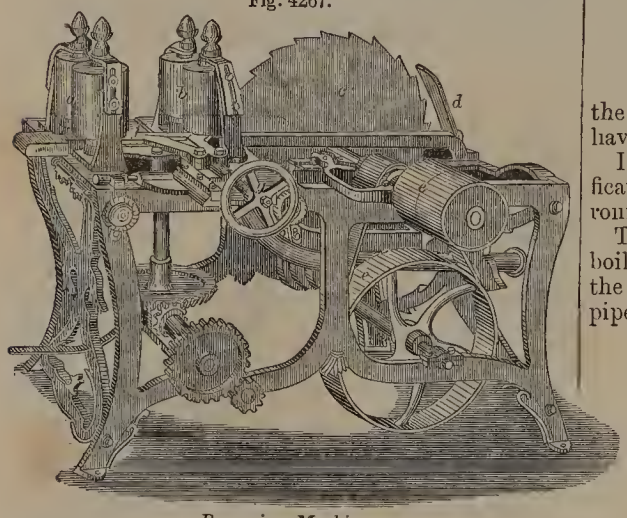
Re-saw'ing-ma-chine'. (*Wood-working.*) A machine for cutting up squared timber into small stuff or boards.

In the machine, Fig. 4266, a reciprocating-saw is employed. The longitudinal feed is effected by the usual vertical rollers, rotated by gear connection with a shaft caused to revolve by a pawl at the end of a lever connected with the journal of the pitman, which causes the reciprocation of the saw-frame.

A hand-crank and screw control the transverse feed of the stuff.

In Fig. 4267, the squared piece to be cut up is drawn between the adjustable feed-rollers *a b*, by which it is presented to the saw *c*; the sword *d* guides

Fig. 4267.



Resawing-Machine.

the severed board and prevents its fouling the operative mechanism. The roller-turning and saw-rotating gears are driven by the band pulleys *e e*, and the transverse movement of the carriage *f* may be effected by turning the hand-wheel *g*.

Re-serve'-style. (*Cotton-manufacture.*) A method of calico-printing in which the white cloth is impressed with figures in resist paste, and is afterward subjected first to a cold dye, as the indigo vat, and then to a hot dye-bath; the effect being the production of white or colored spots upon a blue ground. Also known as the *resist-style*.

Res'er-voir. 1. A pond for containing a supply of water for canal supply, irrigation, or the use of dwellers in cities.

A reservoir erected by Nebuchadnezzar at Sippara was 140 miles in circumference.

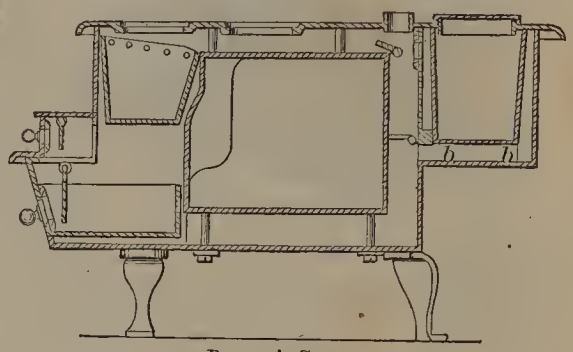
The lake of Mæris, constructed by the Pharaoh of that name to receive the superabundant waters of the Nile at the time of overflow, and afterward yield them for prolonged irrigation, was described by Diodorus Siculus (60 B. C.) as existing till his day. The circuit he gives, 3,600 furlongs, is almost incredible. The canal connecting it with the river was 80 furlongs long and 300 feet wide. Sluices commanded the water-way by opening and shutting.

The reservoir on Mill River, Mass., which burst with immense damage to life and property, May 16, 1874, was an artificial lake between high hills. The confining dam at the lower end was a stone-wall five and a half feet thick at bottom, three feet at the top, and 25 feet high. This wall was about 300 feet long, built of uncut stone from a foundation four feet below the level of the ground at the lower side, and was backed on the upper side with a bank of earth interwoven with branches of trees. The dam had been built eight years at the time of the catastrophe. See DAM.

2. An attachment to a stove or range to hold hot water.

It is heated by proximity to the stove itself or to

Fig. 4268.



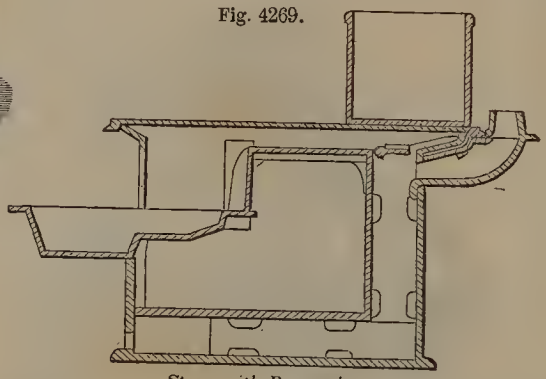
Reservoir-Stove.

the stovepipe. In Fig. 4268, it is behind the stove, having a flue *b b* around and beneath it.

In Fig. 4269, it is on top of the stove. In a modification of the latter form the boiler is made to surround the stovepipe.

The reservoirs of ranges are usually vertical iron boilers, connected by pipes with the water supply of the city. The water from the main passes through pipes in the fire-chamber, or through a water-back,

Fig. 4269.



Stove with Reservoir.

and thence to the boiler. A pipe from the boiler proceeds to the sink to supply hot water at that point, a branch leading to the bath-room and another to the laundry.

Res'er-voir-stove. One having a large boiler attached, to be constantly heated by the fire in the stove. See RESERVOIR.

Re-sid'u-a-ry-gum. Also known as *candle-pitch* or *chandler's gum*. The dark residuary matter from the treatment of oils and fats in the manufacture of stearine. It is darkened by the action of acid, and thence derives its name. It is used in coating fabrics for the manufacture of roofing, and combined with tar and asphate in making mastics and cement.

Res'in. A vegetable product composed of hydrogen, carbon, and oxygen. Distinguishable generally from gum by its solubility in alcohol and insolubility in water, while gums are soluble in water and insoluble in alcohol. There are many varieties of resins, derived from different species of trees. Some are naturally combined with the gums, forming what are known as gum-resins. Both these and the pure

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